CORN STOVER HARVEST

GROWER, CUSTOM OPERATOR, AND PROCESSOR ISSUES AND ANSWERS

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Scope

The corn stover collection experience of Great Lakes Chemical Corporation and Dickey Environmental Corporation in the 1997-1998 and 1998-1999 crop years is documented from the perspective of grower, custom operator and processor. Included are descriptions of the following activities:

- Advance preparation
- Obtaining grower commitment
- Harvest preparation
- Harvesting operation
- Storage site selection and Inventory management
- Transporting the material between farm and processing plant
- Equipment performance

These are the first large-scale collection operations successfully completed, approaching 100,000 acres total.

Purpose

The purpose of the report is to provide an understanding of the activities, contracting processes, social, economic and environmental issues that affected the collection, storage, handling and transport of corn stover for the two companies.

Introduction

Two companies, Great Lakes Chemical Corporation (GLCC), Omaha, NE and Dickey Environmental Systems Corporation (DES), Sharon, WI established large-scale collection of corn stover to be used as a raw material for their production. Corn stover is the surface residue after the corn kernels are harvested. Stover includes the stalk, leaves, husks and cobs. The experiences encountered in harvesting, collecting and storing corn stover during this undertaking are described based on the 1997-1998 and 1998-1999 crop years while working with these two companies.

The needs of the two companies are different. GLCC was searching for a lower cost feedstock to replace oat hulls used for furfural production. Corncobs were originally used for furfural production since they contain a large xylan fraction, about 22%. With current combines, the cob is left in the field with the other surface residue. Oat hulls are a satisfactory substitute, but cost $100 or more per ton. GLCC determined they could bale, transport and pelletize stover containing 18% to 20% xylan for processing to furfural at about half the cost of oat hulls. Their primary requirement for bales was moisture below 30%.

DES was primarily looking at corn stalks to be used for premium horse bedding. The pith contained in the stalk has superior liquid adsorption properties compared to straw and wood chips. The corn stalks *are* the product, so raw material specifications for collection, storage and handling are more stringent, with moisture of 15% to 18%. No material discoloration is allowed.

Other differences included bale type, harvesting, storage conditions and pre-processing steps. GLCC accepted round or square bales of any size. They relied on custom harvesters to provide their own equipment. DES provided most of the harvesting equipment, including choppers, rakes balers with accumulators and only processed large square bales. In the '98-'99 crop year they did contract with some custom operators, but only those with large square balers.

Outside storage was acceptable for GLCC since color is not a factor. Inside storage was required for DES to avoid the surface discoloration of the baled product. Even then, DES rejected a significant portion of baled product due to discoloration or high moisture. GLCC rejected nothing, even waiving the moisture limit during the '97-'98 harvest when wet conditions prevailed.

Preprocessing for GLCC just involved tub-grinding and pelletizing to reduce the bulk density enough to fully charge the hydrolysis reactors where the stover is dissolved and processed to the various chemical components. Most of the lignin is burned for fuel. Some is sold as an adhesive. The ash, mostly P and K is recycled back to the fields for application as a nutrient. Pelletizing also simplified handling and lowers transportation cost from the collection center in Harlan, IA to Omaha, a 60-mile distance.

The DES process includes a size reduction step also, using a knife mill to better expose the pith. Low moisture is required, 15% or below, to achieve the desired surface area for absorption. The material is then bleached, scented and packaged in "peat moss" sized bags for distribution to retail outlets. Recycling of used bedding is not as direct due to diverse distribution, bulk and distance.

There were a number of similarities in the operations. Both companies chose to locate their operations in areas with high corn yields to minimize baling cost. However they both transported over a relatively wide area to insure adequate raw material collection. GLCC requirements were available within a 15 mile radius, yet they contracted over a 50 mile radius. DES established two collection points even more distant: one in Wisconsin and a 2nd in McLean, IL, trucking the bales directly from the field.

CHAPTER 1: ADVANCE PREPARATION

In order to be consistently successful year after year corn stover collection needed to mirror the grain harvest and have a full harvest mentality: operations must be in action regardless of the weather or time of day or night.

The majority of corn producers are not equipped for hay or corn stover harvesting nor do they have the extra people or management time during the grain harvest. Therefore, the stover harvest needed to be performed by local producers equipped for hay harvesting and custom harvesters from other areas with similar equipment. Arranging for these resources months before the harvest is required.

Additionally, GLCC needed to keep raw material cost as low as possible to compete with Chinese, South African and other world furfural suppliers. Balancing producer profit with the manufacturer's feedstock cost is an age-old dilemma. Corn stover harvest needs to be a win – win for both.

Advance planning to best manage this balance is essential: keeping the harvest area travel time manageable, assembling a capable and committed group of workers, training balers to deal with corn stover and generally answering the multitude of individual needs is most important for success.

1.1 Cost of Harvest

Major cost components include labor, equipment, fuel, bale wrap or twine, moisture requirements and transportation distances. An initial survey is needed to gauge the parameters for these factors and also sense the social climate for collection.

1.1.1 Labor

In most rural areas labor is at a premium in the fall harvest season. Several factors contribute. The younger side of the farm labor pool returns to school before the stover harvest begins. The vast majority of corn stover is harvested after September 1st. The senior side of the farm labor pool in rural areas contains many retired farmers that have the necessary skills to be of value to a corn stover harvest. However, few of these retired farmers are available as most are helping in their son or daughter's farm operation during the harvest of the grain, farm fertilizer application and fall tillage work.

Local truckers are also difficult to obtain because they too are busy moving grain. All of this farm activity lessens the availability of the normal labor pool. Contract harvesters coming in from other areas of the country may not be familiar with the local fall shortage of labor. Most want to hire rake operators or fill some of the other positions requiring less skill with local labor.

Harvesting of dry corn stover --20% moisture or less--is usually accomplished when Mother Nature allows and it is not necessarily between the hours of 8 a.m. and 5 p.m. This point needs to be conveyed to potential workers prior to hiring in order to minimize absenteeism. Workers also need to be made aware that harvesting in the rain is not possible. Frequent checking with management is needed as rain is often spotty and even though it may be raining where they are it may not be a few miles down the road.

Even though the actual harvest occurs in the field away from traffic, equipment is moved via public roads from field to field. The implements being pulled by the tractors are often wider than half of the road. Pre-harvest safety courses are beneficial and in some states are mandatory.

Hourly wages are dictated by the laborer's availability. The corn stover harvest window is small and every hour that can be utilized when conditions are right is tremendously important to the success of the harvest and the company. Dependable people are imperative. Paying a few more dollars per hour premium to encourage a larger number of applicants from which to choose is wise.

1.1.2 Equipment Cost

Cost was calculated for five different equipment operations: baling, staging, loading, hauling and stacking. Equipment performance is discussed in Chapter 7.

Baling: Three types of balers were considered: round balers, intermediate and large square balers. All three types can achieve 9 dry lbs/cubic ft. of bale. The normal price of the large round baler (5'X6') is $10 per bale (mesh wrapped) or $15.73 per dry ton.

Normal price of an intermediate square baler (3'X3'X8'5") is $1.00 per linear foot or $24.70 per dry ton. Normal price of the larger square baler (4'X4'X8'5") is based on $1.75 per linear foot or $24.25 per dry ton. Square balers produce bales of varying length to accommodate the producer's equipment. Typical lengths are 6 ft, 8ft and 8.5 ft.

Baling for GLCC has advantages over baling for individual farmers. They offer much more volume, allow higher moisture bales and offer mesh wrap or twine at wholesale prices. With this in mind, price for baling was set at $14.60 per dry ton. GLCC expected few square balers to participate due to local availability.

The majority of round balers were John Deere[1] type using a knife attachment by an OEM supplier, Heartland Mfg., to chop the stalks into 4 inch pieces for improved bale density.

In the DES operation, square bales were preferred since bales were stored indoors. They preferred using large square balers and price was negotiated with each contractor. 4'X4'X8' bales averaged $1.42/linear ft., $11.43/bale, $18.30 per wet ton (under 18%). Estimated dry ton cost, assuming 14% moisture is $21.40 per dry ton. Baler operators produced bales containing 8 to 9 dry lbs/cubic ft.

Staging: Staging or road siding of bales was included in the hauling operation in the GLCC project, and estimated to cost $3.25 per dry ton. This is an average cost for the tractor with the bale wagon. A calculation was not attempted for DES.

Loading: Loading of bales onto trailers after they had been staged or road sided cost around $1.70/dry ton in both operations, and was included in the hauler cost with GLCC.

Hauling: GLCC contracted for most of their hauling with one contractor using special equipment. In the DES project, semi-truck haulers were paid from $45 to $50 per hour depending on trailer type. Both are described in 3.2.4 Transportation.

Stacking: Once loads arrived at the plant they were stacked at an average cost of approximately $1.00/dry ton.

Other optional operation costs included flailing the stalks followed by raking to form a windrow:

- Flail shredding at $2.50 per ton wet.
- Raking at 95 cents per ton wet.

1.1.3 Fuel

Fuel is a component in harvest as well as transportation costs. In both the DES and the GLCC projects, buying in volume reduced fuel costs. Storage tanks were purchased or leased that could hold 130% of a single transport's maximum volume or about 10,000 gallons. By utilizing compartmentalized tanks or two tanks the transports could deliver both truck fuel and farm fuel. This reduced farm tractor fuel cost by 25% and truck fuel by 15%. Fuel was delivered directly from the terminal reducing handling and service charges.

[1] Names are necessary to report factually on available data. The use of a name implies no approval of the product or excludes others that may also be suitable.

In the GLCC harvest most of the stover was transported to the plant using high-speed (40+ MPH) JCB farm-type tractors. Fuel for farm-type tractors is tax exempt. At the end of the first harvest season a comparison was made between 1997 FL80 Freight liner trucks with 275 HP Cummins engines with automatic transmission versus JCB tractors with 185 HP Cummins engines pulling identical bale trailers. The savings favored the JCB tractors by 49 cents/dry ton hauled. This savings is somewhat reflective of federal over the road fuel tax of 24.4 cents/gallon and State of Iowa fuel taxes of 22.5 cents/gallon costs incurred by the Freightliners and not by the fuel tax exempt JCB farm-type tractors.

The loading and transportation costs for fuel incurred by the JCB units averaged 72 cents/ dry ton delivered while the freightliners averaged $1.21/dry ton. The average hauling distance in this comparison was from a 24-mile radius or 48 miles round trip and included fuel used picking up bales as they were placed in the field by the baling operation in addition to travel.

1.1.4 Twine Or Wrap Cost

Plastic twine for the large square bales and DES purchased surface mesh wrap for the large round bales in volume and GLCC in order to receive wholesale price discounts. The savings was passed on to the baler operators; however, a small handling charge was added.

Custom operators were also allowed to purchase twine and wrap for their other needs. The savings to the custom operators were returned to the companies in the form of reduced rates for baling. Those savings were 50 cents per bale. Since at least as many bales would be produced by other baling operations throughout the year, the total benefit to custom balers was $1.00 per bale in reduced cost of wrap.

Normal retail cost of three wraps on a large round bale equals $2.10 to $2.30. GLCC's cost of three wraps on a large round bale equals $1.60 to $1.80. Normal retail twine cost of a 4'X4'X8' large square bale is $1.00. The twine cost for a 4'X4'X8' large square bale at DES was 72 cents.

1.1.5 Operating Moisture

Deciding acceptable moisture level needs careful consideration. The stover moisture at corn harvest is 35% or more. After 3 days of good weather it usually drops below 20%. Measuring the moisture is difficult in the field. The particles are not homogeneous. Measuring moisture in a windrow results in even wider fluctuation as the interior composition differs from the surface.

DES set an extremely low moisture level of 18%. While the low value insures minimal deterioration in storage, it reduces the harvest time window and adds cost. The smaller window requires more equipment to meet the harvest goal. More equipment means more cost in equipment, labor and management. Gearing up and shutting down the harvest takes the same amount of time regardless of whether it is 2 or 16 hours of operating time. Workers want a minimum of four hours paid each day they show up for work. Transportation also costs more per delivered ton along with difficulty caused in dispatching.

GLCC set 30% or less for the average bale moisture. In the 1997-98 harvest the average moisture was just under 27%. It ranged between 11% and 35%. When the moisture was above 35% the balers experienced too many other problems to continue operations. Most of the higher moisture was baled later in the harvest season and deterioration was minimal during the winter months.

1.1.6 Reducing Partial Loads

When delivering bales from a producer's field the last trip is normally a partial load. To best utilize the hauler's time and keep cost low we opted to complete the load in the nearest field before proceeding to the plant. A note was made of how many bales belonged to each producer. Net weight on the load were divided by the total number of bales on the load and then multiplied by the number of bales belonging to each producer. Producers were made aware of split load procedures at the time of procurement. Many split loads were delivered and handled without any complaint from producers.

1.1.7 Transport Distance

At the beginning of the '97-'98 stover harvest season, GLCC set four fixed transportation brackets in an effort to keep it simple.

Table 1
GLCC 1997-1998 crop year
Hauler Pay per dry ton,

Loaded Miles	0-10 miles	11 – 30 miles	31 – 50 miles	51 – 70 miles
Pay, $/Dry ton	$6.10	$8.77	$11.44	$14.10

The mileage ranges were too broad according to many haulers. In response to their comments, mileage was further broken down in the spring of 1998. Additional discussion is provided in Appendix A, Stover Hauling Considerations and Profitability.

Table 2
GLCC Revised Hauling Rates

Loaded Miles	1 – 5	6 – 10	11 – 15	16 – 20	21 – 30	31 – 40	41 – 50	51 – 60	61 – 70	71 – 90	91 – 125
Pay, $/ Dry Ton	5.60	6.60	7.85	9.60	12.10	13.10	14.10	15.10	15.60	16.10	17.10

1.1.8 Component Separation

Cobs contained in the stover were troublesome in both processes. For GLCC it extended process time, as cobs are more difficult to digest in the hydrolysis step. For the DES produced horse bedding, the small stone-like cob particles made walking in the stalls uncomfortable for both man, woman and beast.

Separating the cob would improve both products. GLCC could process the cob directly, without the cost of pelletizing and reduce batch variations. It could also be sold for other applications such as industrial abrasives, chemical carrier or cat litter.

Some of the easily accessed corn stalk pith could also be considered for separation to be sold as a higher value adsorbent. The pith is more absorbent than other parts of the corn stalk. Fiber can be used in papermaking. In the US, more than 97% is now sourced from wood, with cotton and flax sharing the small market. Heartland Fibers has been attempting to commercialize the de-pithed fiber to paper for more than ten years without success. Improved economics from processing other co-products is expected to improve the likelihood of success within the next 3 to 5 years.

1.2 Identify Defenders and Opposition

Resistance to the GLCC corn stover program was anticipated from several potential sources that could adversely affect producer participation. Knowing this, it was decided to contact them directly to insure there was a full understanding of the GLCC program, requesting their advice.

As part of the preparation for these meetings, research articles and other facts showing nutrient value were collected and used to show the benefits for the soil and the producer. Appendix B.

1.2.1 Soil Conservation Service (SCS)

Meetings were set up with local SCS office personnel. The discussion included how this program might affect soil conservation compliance, compaction and tillage practices. It was a general consensus among those involved that only with experience could the effects be measured. A corn stover harvest within the 40 to 70% range was not expected to cause a negative effect. By avoiding slopes steeper than 6% -- especially in drought years, reducing the need for tillage and creating a financial benefit for the producer it was felt the effects should be positive.

1.2.2 Extension Agents

Visits were scheduled to extension offices in each of the counties expected to have producer participation. Discussions with extension agents usually revolved around nutrient content and whether or not producers would be adequately rewarded for the corn stover. There was some concern regarding nutrient value removed and if producers farthest from the GLCC Harlan Plant would be adequately rewarded. In all meetings the extension agents provided names of producers they felt would benefit or at least participate regardless of their personal concerns.

1.2.3 Lenders

Lenders had no conflict or contradictory remarks regarding nutrients or soil erosion potential. They generally accepted the research results presented by GLCC. Most were supportive and some enrolled acres they controlled into the GLCC program. Others offered to have GLCC representatives speak to producers at a producer meeting sponsored by the bank. One expressed concern was how landlords would perceive the stover harvest.

1.2.4 Landlords

Landlords are a most diverse group. Many are absentees, living in other parts of the country. Most landlords are older, well into their retirement years and a large portion are women. Some were very receptive, but most had concerns as to how a stover harvest would benefit them.

One scenario presented was that if the producer demonstrated harvesting corn stover is a dependable source of income and reduces tillage and chemical expense, and then it becomes a part of the producer's business plan. The income and savings derived from the grain and stover harvest dictates affordable rents and land values, which in turn generates additional income for the landlords.

This was suggested to producers who were unsure of how to best approach their landlords. Although exact results were not tracked, qualitative feedback indicated this approach had a positive effect.

Some landlord/tenant rental contracts contain a clause that prohibits removal of stover. With most landlords this is negotiable. However, many producers were reluctant to ask the landlord to consider stover removal fearing it would result in a rent increase or possibly disrupt the relationship.

1.2.5 Producer Meetings

Several producer meetings were held at the onset of the GLCC program to help in the initial planning. These producer group meetings were kept small, less than 12 producers per meetings to better insure full discussion. Producer groups from nearby communities initiated some of these meetings while other meetings were sponsored by GLCC.

Meetings in which stover acres were committed came later during one-on-one meetings with producers. In most situations producers needed to include partners, wives, sons or others involved in the decision making process and preferred to contract or sign commitments in more private surroundings.

With DES, all meetings with producers were one-on-one. No group producer meetings were held.

1.3 Grower Issues

Like landlords, growers are diverse. What appears to be more important to one grower might be of minimal importance to another. There are an extremely large number of variables to be considered. To help speed up their decision-making process a list of interesting points was prepared along with a worksheet titled "Value of Average Corn Crop. The worksheet was originally based on statistics and data from western Iowa and the GLCC harvest methods. A similar version proved to be equally effective in Wisconsin and Illinois. Appendix B has the Iowa version.

The worksheet develops the value for an average corn crop based on the past five years harvest for the particular county using local data. Space was provided for the farmer to enter their individual estimate for each factor including seed, chemicals, equipment, fuel, labor and land cost. In the example this amounted to $24.19/acre

The value added for corn stover harvesting was next determined. Included with the analysis is supporting data addressing the issues of nutrient value, sustainable removal, effect of crop rotation of the two most likely cases: corn-corn and corn-soybeans and other factors such as tillage practice and reduced chemicals for weed and pest control. In determining the bottom line, only the revenue for corn stover was included for the producer based on distance from the collection center.

TABLE 3 summarizes the pricing structure for two cases. Rationale for the differences is described in the remainder of 1.3 and in 1.4.

Table 3: GLCC 1997-1998 Corn Stover Pricing Summary
Payments, Dollars per Dry Ton

Radius, Miles	0-15	16-30	31-50	51-100
Producers Revenue				
1) 1.5 dry ton per acre	$15.00	$ 12.33	$9.66	$ 7.00
2) >2.5 dry ton per acre	$10.90	$ 8.23	$5.56	$ 2.90
Baler's Revenue	$14.60	$14.60	$14.60	$14.60
Hauler's Revenue	$ 6.10	$ 8.77	$11.44	$14.10
Total, Case 1	$35.70	$35.70	$35.70	$35.70
Total, Case 2	$31.60	$31.60	$31.60	$31.60

The corn stover operating profit example is worked out below:

GLCC pays (11 – 15 miles) $15/Ton (1.5/Acre) To the producer for providing the windrow	= $22.50 / Acre
Nutrient replacement	= $ 10.40
Net additional income	= $12.10 / Acre
Savings of one field cultivator pass	=$ 7.10
	$19.20/Acre for corn stover
Normal profit without stover harvest:	$24.19/Acre for corn
Profit with stover $19.20 + $24.19:	$43.39

In the above example, operating profit is increased form $24.19 / Acre to $43.39 / Acre. with little or no additional risk using custom operators. Excluding transportation and baling costs the average producer participating in GLCC programs received $12.90/dry ton and those participating in the DES programs received an estimated $.0072 cent/lb. Or $14.40/wet ton (up to 18% moisture). The farmer can increase his revenue and operating profit further by baling and hauling the corn stover. Most chose to leave the collection to others while they concentrated on harvesting the conventional "cash crop."

1.3.1 Residue Value

When most producers estimate the values of corn stover there are basically three considerations: nutrients, organic matter and erosion control.

Establishing the value for nutrients is difficult to generalize. Nitrogen is perceived to have no value in corn-bean rotation. As indicated in the Appendix B worksheet an average of $10.40 was used for phosphate and potash the 1st year. Based on extensive sampling it was revised to $4.56/dry ton the 2nd year.

For producers with large livestock operations --usually planting continuous corn--the stover had no nutrient value. . . especially where hog operations have caused excessive soluble phosphate to become a serious concern in the area's water quality. These producers were anxious to have some removed.

Organic matter is not usually raised. Recent research by C. Cambardella and D. Reicosky, USDA ARS indicate that most organic matter is from roots and plowing results in its destruction.

1.3.2 Amount Removed

GLCC and DES expectations in both harvest were that 1.5 dry tons/acre of corn stover would be collected. GLCC collected 1.25 dry tons per acre. For DES the estimated result was 1.55 tons -- based on an average of 3,790 lbs "as is," and 18% moisture. Moistures were taken to avoid material exceeding 18%, but records were not kept to determine average moisture. In all cases more than 30% of the residue covered the surface for erosion control.

One farmer in Iowa complained that too much was removed. Several other farmers in Iowa and Wisconsin mentioned more should have been taken. No reaction was received from the Soil Conservation Service in either harvest project.

Grain yields were not tracked as part of the record for either harvest. Conversations with producers indicated western Iowa yields varied from 130 to 180 BU/Acre. The DES Wisconsin harvest was 150 to 200 Bu/Acre.

1.3.3 Timely Harvest

Producers were sometimes frustrated by the harvest crew's ability to be timely. In the DES operation, stalks were flail chopped. Several days elapsed after flailing, waiting for moisture to reach18%. Some producers did not wait and proceeded with their fall tillage. However, this was somewhat reversed with no-till producers and those in river bottoms with loess-type soils (a soil with fine silt particles, mostly sand and clay). They were more relaxed and less concerned with a quick harvest, preferring the ground frozen or fairly dry before harvesting the stover. The only exception was on the loess soils with one producer wanting to V-rip the field to overcome compaction.

To gain a higher degree of satisfaction among producers in future harvests it is important to decrease the time between combining and corn stover harvest. New methods of harvesting and perhaps drying should be explored to accomplish this.

1.3.4 Removal Method

In the 1997-1998 year GLCC Stover Harvest Program two harvest methods were offered. The first was for the producer to shut off the spreader and/or chopper on the combine. This made a windrow of cobs, shucks, leaves and some stalk. The baler (predominantly round type) then harvested the windrow left by the combine.

This resulted in collecting 40% to 50% of the stover depending on combine head size. A twelve-row head forms a windrow three times larger than a four-row head. The four-row head in most situations does not create a big enough windrow especially for the large square balers. Increased payment per ton (but less per acre) was offered for this method since it was expected to collect more cobs, referred to as Case 1 in Table 3. The cob has more value for GLCC's furfural extraction process than other stover components.

The second method, Case 2, raked the field to collect up to 70% of the corn stover. Skipping rows was allowed. This method generated more income per acre but paid less per ton since the stover contains a lower percentage of cobs. Square balers normally preferred this type of harvest.

The windrow dries slower than when the stover is left in the field and then raked after the desired moisture level is reached. A trade off between an extra operation, the amount collected and collection urgency must be made between the two methods.

For GLCC, round bales were removed from fields with automated bale pickers and hauled directly to the collection center (Figure 1). The bales were sampled, weighed and then automatically off loaded at GLCC's plant (Figure 2). Square bales were either collected on an accumulator behind the baler (Figure 3) or picked up by an automated bale picker and moved to the field's edge (Figure 4) where they could be reloaded onto flatbed trailers pulled by semi-tractors (Figure 5). These loads had to wait for GLCC personnel to off load using spears or squeeze trucks.

For DES and some GLCC fields the stalks were first chopped using a flail stalk chopper (Figure 6). When moisture was judged to be less than 18%--usually requiring 2 to 3 days of favorable weather after combining if no rain-- V-style rakes formed windrows (Figure 7). Within a few hours of the windrow's creation the balers arrived to harvest the material the same day. If left overnight, dew forms raising the moisture above 18%, delaying the baling until 11AM or later the next day, dependent on favorable weather.

No bale picker was available, so after baling, telescopic loaders with bale squeeze attachments gather the bales into groups of 24 or more (Figure 8). Then semi-tractors with flatbeds would be dispatched to the field near the groups of bales where a loader would place the bales on the trailer. After transport to the final destination other telescoping loaders off load and stack the bales in the warehouse.

The GLCC operation was considerably cheaper -- about $37.00 per dry ton stacked in the open field at the plant. DES costs were nearly $50.00 per dry ton stacked at the warehouse. Warehouse storage costs were additional.

1.3.5 Broken Bales

Broken bales can occur when wrapped improperly, equipment or wrap fails or foreign matter is trapped in the stover. The harvest has to be consistently clean. Broken bales, plastic twine or net must be minimal. Farmers will not accept anything foreign or abnormal left in their fields. Twine or surface mesh can wrap around axles and other rotating parts of their equipment. Excess stover and uneven surface cover may adversely affect the next crop, interfering with chemical application and soil warming.

The average number of broken bales seems to be about 3%. Percentage varies among baler operators and field situations, such as operator experience and fields containing dirt or soil clods left from cultivation.

If farmers perceive the need for them to clean up after baling, they may envision a greater cost or bigger problem than it actually is, reducing producer participation. Better methods of dealing with broken bales needs to be addressed.

1.3.6 Windrow Removal

No matter how the windrow is accumulated it is always a concern to the producer. His fear exists because if the weather turns against the stover harvest or the company fails to complete the harvest. The producer may have the expense of redistributing the windrow. Most producers do not have the proper equipment to do so, nor can the windrow be redistributed as evenly as if it were never made in the first place. An excess of corn stover where a windrow has been gathered but not harvested can cause slower emergence of the new seeding, more problematic planting or tillage, (NH_3) anhydrous application and less uniform weed control. Last, but not least, an excess of corn stover can make a more ideal habitat for cutworm as was experienced by a few producers in both the DES and the GLCC harvests.

1.3.7 Compaction

Compaction is always a concern for producers because it can adversely affect the soil's future productivity. Harvesting of crop residues can again have a positive or negative affect on compaction. In the northern part of the country where frost can cause the breakup of compacted soil, fall compaction is not quite as a concerning as springtime compaction. However, it can still be a serious problem. Harvesting of grain with the combine takes place and so can harvest of the crop residue, provided that there is some type of benefit for the producer and that a reasonable effort is made not to compact. The effort should be similar to or more so than the effort made by the producer in his grain harvest. By removing some of the residue produced, compaction can be reduced. Removing residue to any extent improves exposure of the soil to movement of air and the sun's drying ability. A drier surface when springtime planting takes place can reduce compaction. Spring planting is completed within a very short window of opportunity and quite often under wetter than desirable situations.

1.3.8 Post-Harvest Tillage

In many areas in the Corn Belt fall tillage is preferred, at least chisel plow or major tillage. Fall plowing is by far the easiest for managing heavy soils. If you plow when the soil is too wet the winter weather will largely correct your mistake. To a corn stover harvest operation this means your window of opportunity for completing a stover harvest is not only at risk to the onset of winter weather, but also the producers plow. If producers intend to fall plow they will need to accomplish this task before any freeze. In southern Wisconsin and on the river bottoms in western Iowa several fields previously committed to the stover harvest programs were canceled so tillage could take place rather than wait any longer for balers to get there and complete their task. This was far less of a problem on fields with slopes.

1.4 Establish Price

1.4.1 What Are the Local Existing Prices?

It is relatively easy to find present market prices of corn stover and most bedding products including low quality hay, cane hay and sorghum stover. Many agricultural publications list producers and brokers wanting to sell hay and forages. In Iowa the Hay and Straw Directory is a good source published by the Iowa Department of Agriculture. The High Plains Journal, Dodge City, Kansas also contains many classified ads with corn stover or similar products for sale. Calling the producers and brokers listed can quickly provide a price range. Hay auctions and livestock sale barns are other sources for establishing a range of prices paid to producers for corn stover and similar products.

1.4.2 Set Delivery Price

GLCC used the end product value for furfural to establish the delivered price for corn stover they could pay. An example at 40 cents/pound furfural follows:

One dry ton corn stover X 18% furfural potential X 70% GLCC's yield = 252 lbs furfural X 40 cents/pound = $100.80 processed value for each ton of stover. Subtracting processing cost resulted in $31.60 per dry ton delivered to the Harlan facility.

The average market price for bedding was higher, $35 to $40 or more per dry ton. Unless a 2nd tier price was offered it was felt that producer commitment for 50,000 acres would be difficult to obtain within a reasonable transportation radius. Expected participation would only come from producers closest to the Harlan collection point, pork producers with high levels of phosphorus and a limited number of other producers that for one reason or another felt they had excessive or harmful amounts of corn crop residue on certain fields.

Three possible options to increase the delivered price were considered:

1: Increase efficiency at the processing facilities and pass savings on to producers
2: Increase furfural content in the raw material (corn stover) thereby increasing the value
3: Reduce harvest costs and pass savings on to producers

While all are feasible, option number one and three occur over time. Option number two was immediate if the percentage of cob and shuck could be increased. These contain higher xylan and potential furfural: 22% and 20% respectively. The lower leaves and lower stalks contain 16% and 15% respectively.

Stopping the spreader and/or chopper on the combine produces a windrow containing all of the cobs and most of the shucks, estimated to be 20% xylan. The recalculated price increases 13% to $35.70 per dry ton for this scenario. Most important, it was all going to the producer. Balers and haulers also benefit since the windrow was preformed, eliminating the raking operation. Including more cobs also increased bale density, reducing transportation costs.

After this analysis GLCC decided to offer two choices:

1. Harvesting just the windrow left by the combine, paying $35.70 per dry ton for the higher fraction of xylan
2. Harvesting up to 70%, paying $31.60 per dry ton when the field was raked to bring in more stover, but with a lower xylan composition.

The overall result was a significant increase in the producer's willingness to participate.

1.4.3 Setting The Producer Price

With the GLCC delivered prices now established, the producer could decide on a higher price per ton by choosing to commit just the windrow left by the combine or a higher price per acre by harvesting the entire field. Table 4 summarizes the result.

TABLE 4
Corn Stover Revenue and Producer Net per Acre

Harvest Choice	GLCC Price $/dry ton	Harvest/acre Dry Tons	Revenue per Acre	Producer Net per Acre
Combine Windrow	$35.70	1.5	$53.50	$10.50-$22.50
Rake Field	$31.60	3.0	$94.80	$8.70-$32.70

The amount of stover per acre collected for just the windrow was 1.5 dry tons maximum, limiting stover payment to $53.55/acre. The producer receives $10.50 to $22.50 after subtracting baler and transportation cost, depending on the distance from the collection center.

If the producer chose to harvest stover from the entire field, about 3 dry tons per acre is expected for a corn yield of 180 Bu/acre --collecting 70% of the surface residue. Total revenue is increased to $94.80, with the producer potentially receiving more per acre, dependent on transportation cost.

1.5 Accessibility and Hazards

Collection radius is a general indicator of potential harvest size and cost limits. State regulatory limits, legal restrictions, local soil conditions, highways, bridges and related conditions must be assessed for each situation.

1.5.1 Regulations and Restrictions

For GLCC to legally harvest corn stover, some Iowa laws were changed to accommodate wide loads of round bales and high-speed tractors operated by custom operators. Special wagons designed for picking up the round bales in the field were too wide to comply with existing laws. These wagons and tractors are equipped with air brakes, beacons and extensive lighting systems. They are fully capable of safely traveling at 45 MPH and more, closer to that of regular traffic than traditional tractors and farm wagons. As a result, they fit into traffic flow better while increasing productivity. The changes in Iowa law were:

- An increase in the allowable road speed for implements of husbandry.
- Allowing custom harvesters the same rights as the farmer in regard to transportation of crops from the farm to a plant.
- Transporting loaded wagons during night hours and on weekends.

In the DES operation all square bales were utilized, so the width of the load was not a major concern and all loads were hauled with semi-tractors pulling flatbed trailers. However, the cost per dry was over 30% higher than the GLCC operation with very little difference in price paid to producers.

Wisconsin and Illinois regulatory differences did affect fuel transport. The DES plant is located one mile north of the Illinois State line in Wisconsin. Harvest crews were often moving from one state to another. Transporting fuel in tow tanks to support the baler operations was made difficult by laws regulating fuel movement across state lines along with differences in allowable methods of transporting.

1.5.2 Drainage

When committing to purchase corn stover from producers it is important to consider drainage, slope and soil type. Some areas drain extremely slow due to soil type and slope. Many producers with these soils have adapted and are capable of harvesting the grain even where there are areas of excessive water by using wide tires or tracks.

Unfortunately, the stover harvest is different. A four inch rain in November can eliminate much of the potential stover harvest, at least when using conventional stover harvest methods. In fields that drain poorly the stover ends up in the water. With short days and minimal available sun this time of year, it is unlikely the field condition will improve enough to harvest. Even then, the poor draining sections often contain shorter stalks making harvest less attractive. To avoid these areas it is often necessary for equipment to drive across the rows. This slows the harvest, increases the risk of equipment damage and can disrupt the field condition for the next crop--all factors to be avoided.

1.5.3 Slopes

Slopes were more prevalent in GLCC's western Iowa operation than in the DES project. Both GLCC and DES wished to avoid refusing farmers offer to contract stover.

Operating on slopes reduces productivity. Normally the steeper the slope the less the potential yield and a need to leave more stover to assure soil conservation compliance. This reduces baling operation efficiency. When picking up the bales with an automated bale picker the risk of mishap also increases as the percent of slope increases. Similar to the fields with poor drainage, slopes may make up a fraction of an otherwise very acceptable field.

A "slope-charge" was developed based on the additional cost the picking and hauling contractor incurred. The slope charge was bracketed and increased in each bracket over 8%: 8% to 10%, - 80¢, 11% to 12%, and >12%, all - 40¢ increments. Fields in question of having above 8% slope were checked using software from PMC Map Pro Company or soil topography maps. This was done if requested by the hauler.

By not dictating to producers where to and where not to harvest corn stover GLCC and DES felt better relations are maintained. Producers accepted the slope charge, as they are aware of the additional cost of operating equipment on slopes. Slope charges also naturally discourage harvesting stover from fields with slopes greater than 8% by reducing the financial incentives.

1.5.3 Soil Type

Soil type impacts the harvest possibilities.

- Silt loams tend to give the widest harvest window because they have good drainage and aeration.
- Clay and Clay loams can pack badly under wheels when wet. They also tend to stay wet longer than silt loams or sandy soils. Producers are generally more concerned with the potential of compaction and water erosion.
- Sandy soil drains quickly and tends to allow a larger harvest opportunity. Sandy soils tend to cause more wear on equipment, especially balers, but also equipment at the manufacturing plant.

1.5.4 Rocks

The GLCC harvest in western Iowa encountered relatively few field situations where rocks were a problem. However, in the DES harvest in southern Wisconsin and northern Illinois rocks were often a concern. Rocks are fairly easy to spot in the freshly tilled field in springtime, but are difficult to see while the crop is growing or even after the grain is harvested. Most often purchase of the corn stover takes place during the period that rocks are most difficult to see. Are rocks expected in the field? What size are the rocks? These are questions that should be answered before committing to the harvest.

A clause in the commitment or contract was not included to address the issue of excessive rocks. The DES agreement stated that if rocks were a problem, harvest in that field would not be completed. Flailing high, keeping the rake off of the soil's surface can avoid most small gravel. Four inch rock or greater should be avoided. If the producer or contract baler can identify where a pocket of rocks is to be expected perhaps most of the field can be harvested.

1.5.5 Cultivation Practices

Although cultivating is not as important of a tool in controlling weeds for most producers today as it was in the past, it is still used. When a shallow scraping is all that has occurred it is unlikely to affect the corn stover harvest. However, if a deep cultivation or any other method leaves large clods of soil in the field the baler will have trouble with mud and dirt building up on the belts and rollers in the case of a round baler or in lower corners of the large square baler. This additional dirt will cause an increase in missed ties and torn wrap, plus adding more dirt to the bale. It is best to avoid fields containing large soil clods by checking the fields for large clods before commitment.

CHAPTER 2: GROWER COMMITMENT

2.1 Purchasing

2.1.1 What's In It For The Producer?

To help explain how the producer could financially benefit from the sale of corn stover the work sheet entitled "Value of Average Corn Crop" was most beneficial. A version of this work sheet was described in Chapter 1 – Section 1.3 Grower Issues. Using it insured all issues were consistently covered. The work sheet develops how the average producer could increase net income 90%. It also provides a basis for the results. An adjacent column allows the producer to incorporate his own figures if he chooses. The producers often requested extra copies of the work sheet for partners, sons or other involved

2.1.2 Farmers as Purchasing Agents

In much of the Corn Belt the period from mid-June to September there is limited field activity. Some producers look to supplement their income during this time. GLCC recruited several near their collection center as purchasing agents in the 1997-98 program. By focusing on local growers to enlist in the stover harvest the collection radius could be reduced. The program was successful and was expanded the1998-99 harvest season. They were paid approximately 50 cents/acre for acres enrolled in the program. A small problem was experienced with one farmer/purchasing agent made verbal promises not on the GLCC Corn Stover Commitment Contract.

2.1.3 Balers and Haulers as Purchasing Agents

Some farmers recruited for purchasing stover were also contracting balers and/or haulers with good success. They have a more understanding of problems that may arise and are conservative as to how timely and systematically things would occur. This eliminated over-expectation by producers in comparison to the farmer/purchasing agent.

In time only balers are likely to be needed as purchasing agents. A baler could work for the same producer year after year, finding replacements for producers no longer participating.

2.1.4 Producer Meetings, Round 2

Meetings with large groups of producers were held initially to introduce the subject. During the purchasing phase one-on one meetings were held with producers. The meetings were usually held at their location and involved the purchasing agent and those affiliated with that operation. Questions addressed the individual concerns and promoted understanding.

2.1.5 Advertising

Direct mailing was done by GLCC the first year. A mailing list of 600 producers with over 500 acres of corn in specified counties in Iowa was purchased from a farm magazine. Response to the mailing was 1%, with six producers expressing an interest.

In the DES program ads in farm periodicals were used. A fair amount of interest was generated, but the coverage area of the publications was far larger than the intended harvest radius. Most of the inquiries came from producers outside of the 25 mile radius of Sharon, Wisconsin.

A booth at the local county fair was also used. and response was not overwhelming but each lead tended to lead to the next. Posters were put up in farm supply stores, feed and seed dealers and grain elevators in both the DES and GLCC projects. All of the advertising methods were helpful, but perhaps only necessary the first year.

2.2 Purchase Contract or Purchase Commitment

The word “contract” may be a bit strong for the present stage of corn stover harvesting. The large-scale harvest had never been attempted before. Until more experience is gained, the word "commitment " left makes both parties more comfortable.

2.2.1 Suggested Contents

GLCC and DES were responsible for the harvest crews and set the allowable harvest moisture. This lack of control by the producer, plus the fear of drought, early snow or extended rainy periods increased their concerns to fulfill a binding contract. Using best effort commitments rather than binding contracts avoided the psychological images that might come into the producer’s mind: lawyers, courts, big companies/versus producer,

From a public relations standpoint GLCC and DES wanted producers to feel at ease with the idea of a corn stover harvest. The word commitment was selected instead of contract. Legal phrases were avoided. Wording was kept simple and easy to understand. Appendix B.

Along with the normal name and address several phone numbers were included to increase the harvest crews ability to make contact with producers if questions existed.

Location of the field was also important to save time and also not harvest the wrong field. Roads are poorly marked. Therefore, each field was identified and mapped. Often the map provided was not used to locate the field, but rather a plat map was attached. These maps were often better than the sketch provided by the producer. This is addressed further in 2.4

2.3 Payment Criteria

2.3.1 By Bale

The conventional method of purchasing bales of hay and straw among producers in the past has been by the bale "as is" without specifying moisture. DES used this method since they had no truck scale. They saw no need to install one and avoided the associated labor cost and a potential bottleneck in the system.

Producers and contract balers readily accepted this method. They could count the bales in their field or on the loads and know their yield. Pay was based on these "as is" bale weights according to number of bales. Random loads were checked to verify approximate weights. These check weights averaged over 1,200 lbs per 4' X 4' X 8' bale and 1,000 lbs per 3' X 4' X 8' bale. Truckers were paid by the load, hour or mile.

2.3.2 By Acre

While estimates of the harvest and producer income were made by calculating expected yield per acre, purchasing by the acre was avoided. Hybrid, soil type, weather, slopes and many other factors affect the yield within a field. The amount of stover per acre in the DES project varied from 2.5 to 6 bales using the same 4' X 4' X 8' baler.

The contract baler often visited the field before harvest to scout for difficulties. Even then, he adjusted to actual conditions as the harvest proceeded regarding wet spots, rocky areas and excessively weedy areas would need to be calculated as to acreage and subtracted from original field size.

2.3.3 By "as is" Ton

DES chose to buy "as is" to avoid the additional scale investment and labor cost for moisture analysis. In the DES project allowable moisture in the bale was limited to 18%. This resulted in some confusion with the producers. GLCC paid based on delivered dry ton. Their data allows better accounting and control, and they believed such controls were essential for their operation.

The point! Allowable moisture will be dictated by the application and the maximum acceptable moisture will vary according to the application. However, it would save reduce confusion if corn stover was bought by the dry ton or adjusted to some standard moisture level.

2.3.4 By Dry Matter

Purchasing corn stover on a dry basis appears to be one of the best options. Calculations and comparisons can easily be made for nutrient removal, actual stover yield and furfural potential. If stover was purchased based on what most would consider an acceptable harvest moisture of 20%, then pay weight would need to be adjusted either up or down. If no adjustment were made for moistures lower than 20% and above 20% was rejected for exceeding moisture limits, then all producers not harvesting at exactly 20% would lose by either being rejected or not including the weight of the allowable amount of water. If an advantage can be had it will always be to the buyer and never the seller.

2.4 Field Identification

2.4.1 Maps

In some cases two types of field maps were used. The township plat map (Appendix C1) gives very precise location and shape of individual's properties and the area where fields were to be harvested was highlighted.

The second type of map used was the township directory (Appendix C2). It does not contain property lines, but does indicate location of farmhouses and names of the residents. These maps also identify roads. This type of map was used as wall maps at company headquarters to show the radius of the harvest area. These plat maps and directories are extremely useful for harvest and transportation crews as well.

Directory-type maps were preferred to give directions over the phone or to re-orient confused equipment operators, especially necessary in nighttime operations. Most rural producers receive these maps free of charge by the publishers. These maps are normally available for each county in a state.

Some publishers include:

Farm & Home Publishers, LTD
P.O. Box 305
Belmond, IA 50421
(515) 444-3508

Directory Service Company, Inc.
950-52 South Sherman Street
Longmont, CO 80501
(303) 530-8650

2.4.2 Field Signs Or Numbers

As part of the preparation, corrugated plastic field markers were made for the DES project. These field marker signs were attached to a steel post at the most appropriate field entrance. Reflective field numbers were placed on these signs that corresponded to field numbers on maps.

The reason for this additional precaution was to avoid using a driveway owned by a non-participating party. Many of the acreage owners as well as producers had asphalt driveways at the farmstead or house. In most cases the asphalt was not thick enough for heavy equipment. The cost of field signs was much less than the potential cost of repairing damaged driveways and the associated complaints.

2.4.3 Map Needs

In the GLCC project four sets of maps were used and one spare set was kept on file.

- The producer needed a map when calling in to report a field ready for stover harvest. The commitment number and field number insured correct identification.
- The contracted baler and hauler also had a copy of this map to locate the field.
- The harvest manager used the maps for documenting and following up on potential problems and producer complaints.

The DES project was more complicated as DES personnel performed a portion of the harvest and different crews (flailing, raking, baling, loaders and hauling) performed five separate operations, plus the involvement of the harvest manager.

A large wall map with all fields highlighted was used at plant locations so if someone needed assistance they could call in and be given directions. Pins with field numbers on them were also used and removed as a field harvest was completed enabling the company's manager a visual of the harvest progression.

2.5 Field Considerations

2.5.1 Rocks

No clause or concern with rocks was needed in the GLCC project grower commitment. Avoiding rock concentrations was easily accomplished during procurement due to familiarity with the area. With few exceptions rocks are a minor problem within a 50-mile radius of Harlan, encountered only in the extreme northeast part of this harvest circle.

In the DES operation there were many rocky areas within the harvest radius. Since the procurement began in June, the crops concealed rocky areas. As a result, a clause that voided the commitment was added if rocks were found to be problem.

2.5.2 Drainage

Many of the fields in the DES project had drainage ditches or shallow tile lines that needed to be avoided by heavy equipment. Producers were asked to mark these areas on the commitment map. A written warning was placed on the commitment map and highlighted in orange to draw attention to them. This warning was adequate. No producer complaints of tile line damage were reported and no equipment operators got stuck trying to cross drainage ditches. In western Iowa the drainage ditches are far more obvious. Tile lines are deep, usually 4' to 6' under the surface of the ground and are not affected by equipment operation.

2.5.3 Field Entrances

Many field entrances are not wide enough to accommodate the longer hauling units. A semi pulling a 52' trailer will give maximum square foot capacity, but many field entrances in western Iowa are impossible to enter. The minimum field entrance width depends on side grades and the width of the adjoining road. Sloped entrances that cause them to become high-centered also stop drop-deck and double-drop-deck trailers.

Many times fields have multiple entrances and the most ideal entrance should be selected and noted on the commitment form. If bales are to be temporarily staged near the field entrance for later loading, the staging crew needs to be aware of problem entrances. Some preplanning will reduce the number of mishaps due to poor decisions on the part of the haulers and stagers. With some advanced planning most all problem entrances can be avoided or resolved.

2.5.4 Producer's Needs (fertilizer application, tillage)

A "special instruction from the producer" area was on the back of each field commitment form. This area was used by the producer to indicate concerns and needs of the producer. Often producers would indicate fields that should receive harvest priority in order to allow early fall tillage or fertilizer application. There was also a clause on the back of the commitment form that stated "if baling has not been completed and the producer wishes to do field work or run cows, the producer should do so at his discretion. However, if this is done, this commitment is canceled." This assured producers that they still had control and if they felt other field operations had to begin and they could not wait any longer for stover harvest to take place it was their decision.

2.5.5 Field Size And Shape

The larger square balers had more difficulty working in small and odd shaped fields than did the large round balers. When assigning fields to balers, if the practical choice existed, round balers were used in those fields. Every effort was made to harvest small fields if the producer desired. Since corn stover harvest affects the tillage practices, chemical choices and other management choices, harvest taking place on one field and not others may cause additional management or even necessitate additional equipment for the producer which in turn could result in reduced participation or harvest benefits.

2.5.6 Harvest Radius

The same considerations that were made for small or odd shaped fields also hold for distant fields. There were fields harvested 20 miles from the next nearest field . . . outside the intended harvest circle. This extreme distance required the baler to travel one hour out and one hour back, towing the associated equipment with a conventional tractor. Although every effort was made to accommodate producers, this one stretched the limits.

CHAPTER 3: HARVEST PREPARATION

3.1 Identify Custom Operators

There are at least three groups of custom operators: the producers, local custom operators and large jobbers that primarily work in the western plain states. For the initial corn stover harvest, few producers have the time or resources to participate. Their priority is harvesting the established cash crops, primarily soybeans and corn. Local custom operators were the best source for GLCC since they had underutilized round balers that were adaptable to corn stover. Large jobbers with square balers were the primary source for DES. DES also purchased enough equipment to meet one third of their requirements--contracting with others to operate it. GLCC relied entirely on the equipment of others.

3.1.1 Producers Themselves

Producers would seem to be the ideal people for the stover harvest as they could harvest both their stover and that of nearby producers. Sixty to seventy producers--about 15% of the total that signed commitments to supply stover-- expressed some interest by attending a baling and hauling conference held in Harlan. However, most decided they would not have the extra manpower until their own grain harvest was completed. Others decided that their baler was too old, would not make a dense enough bale or was not equipped with the bale-wrapping device.

Twenty producers did contract to do their own baling and hauling for the GLCC harvest, contracting from 600 to 2,500 acres each. Their results were uneven. One third did well and put forth their best efforts. One third struggled between their own grain harvest and the unexpected difficulties in baling corn stover. Many of these improved the following year. The final one third never made a real effort and procrastinated thinking they had all winter, which proved to be a mistake.

The lesson learned - have backup balers ready. It is hard to identify the future non-performers. Some risk was removed by setting a maximum of 1500 acres contracted to one baler. Those that finish their contracted acres are offered more acreage from those balers that have yet to complete their contract.

3.1.2 Local Custom Operators

Most local custom operators were an excellent contact for sourcing corn stover balers. Even if they were too busy with present customers to contract for additional business, they were aware of other custom operators and offered referrals. They are also experienced in dealing with producers and persuaded some of their existing hay customers to participate in the corn stover harvest. While they are apt to have more experience in baling corn stover than producers, their reliability was only a little better. This assignment was too often viewed as a sideline, providing supplemental income and did not always have the right priority for timely harvest completion.

3.1.3 Large Jobbers

Many of the western, high plain states produce large amounts of hay that is harvested by large jobbers with multiple balers and supportive equipment. Their normal harvest occurs between June and September and their service is available for the corn stover harvest beginning in mid-September through November. They had minimal experience with corn stover, but were quick to learn. When they bring their crews into an area they only have one focus-- complete the corn stover harvest they are hired to do.

GLCC used custom operators from Iowa, and many from the local area. The DES project used crews from Oregon, Idaho and Illinois. Since some crews were from quite a distance, DES provided some of the preliminary planning, housing, meals, fuel, twine and equipment part logistics. They were willing to contract all aspects of the harvest from flailing to hauling. Most of these large jobbers do work for large feedlots, hay exporters and mushroom producers. All of these baling operations were dependable and well organized.

Contacts include:

- Rod Phelan, Phelan Inc., Tangent, Oregon, Phone: 541-967-8195
- Tom Stevenson, Geneva Enterprises, South Mendota, IL, Phone: 815-539-3040
- Dennis Strom, Strom Ranches Inc., Hill City, ID, Phone: 208-764-2596

3.2 Work Contracts

Contracts with the custom operators were kept simple, developed without the assistance of lawyers and avoided legal terminology. This may not be the best method of contracting if one ends up in a legal battle within the courts. However, if any party failed to complete their contract it was judged to best resolve the conflict outside of the court. If that was not possible, GLCC then felt the effort involved in recovering damage caused by the party who failed to meet the contract outweighed any financial settlement . . . and should be disregarded. Positive public relations are more easily maintained. Individual contracts were relatively small and for the most part incomplete contracts are often the result of weather conditions or can be blamed on weather and gain the sympathy of the court.

3.2.1 Purchasing

Procurement agent's contracts were verbal. Fees paid for acres committed by the producer and submitted by the purchasing agent to GLCC was $0.50/Acre or the equivalent in mesh wrap in the cases when balers were the purchasing agents.

3.2.2 Field Preparation

Field preparation was included in the DES project contract. Most of GLCC field preparation contracting was included in the producer commitments--forming the windrow with the combine. On occasion the balers contracted or came to agreements with the producers to form a windrow without GLCC involvement. Reasons included insufficient size windrows left by smaller four-row combines and ridge planting.

3.2.3 Baler

In the DES project balers were contracted to deliver a specific number of bales or harvest a designated number of acres. A sample of the Baling Contract predominantly used in the GLCC project is provided in Appendix D.

3.2.4 Transportation

In Wisconsin and northern Illinois DES opted to contract with trucking companies by the hour for flat bed trailers or double drop deck trailers, shown below. A double drop deck trailer is a semi trailer with 3 deck heights. The first 10 ft. or so is the highest (about 4'6" from ground to the deck), designed to go over the tandem wheels of the semi tractor. The center deck is only about 24" from ground to deck and extends from behind the semi tractor tires to front of trailer tires (30' or so). The rear deck is just high enough to clear the trailer tires (normally low profile tires) just over 40" from ground to the deck.

Contracts varied from $47.50 to $50.00/hr depending on the type of trailer. In the case of Illinois Fiber and Geneva Enterprises, the transportation cost was included in the delivered bale price.

GLCC purchased mostly round bales from one contractor with special equipment, Iron Horse Custom Farming (IHCF). The price paid to move round bales was not attractive to most haulers with conventional equipment. IHCF purchased self-contained bale loading and unloading trailers and as a result, transportation was mostly contracted with them. This type of equipment is desirable since it is not dependent on others for loading and unloading bales. Examples are shown in Figures 1, 2 and 4 for square and round balers.

GLCC contracted a minimum volume of 40,000 tons annually for three years with IHCC. A pre-established penalty amount is held in an escrow account to be paid to IHCF if less than 40,000 ton was available for transport. Without the contract terms, the perceived risk would have been too high for IHCF (or others) to procure this specialized equipment. Other contractors hauled a small amount (mostly square bales) and a copy of this Hauler Commitment can be found in Appendix E.

3.2.5 Loading, Unloading and Stacking

All loading in the field was the responsibility of the hauler. Efficient round bale handling was a major factor in the limited response by conventional haulers in the GLCC project. The automated bale picking equipment operated by IHCF was able to load and off load independently, requiring no support.

Delays in loading and unloading conventional trucks often occurred. Conventional flatbed trailer operators were required to wait for fork or squeeze equipment in the field for loading the bales AND at the collection center to unload the bales. In the field, the fork trucks needed to be driven or hauled from spot to spot. If a breakdown occurred, no spare fork was available. Also, the fork operator was normally operating another piece of support equipment--the flail or rake since trucks were loaded intermittently. In some cases the truck drivers had to load their own trucks. . . .not a task most can do well. At the processing center several trucks would arrive at the same time and the equipment used to off load could not keep up causing another bottleneck in the system.

3.3 Problem Avoidance

Advance planning is key to avoid problems with wet bales, fire, rodents and insuring safe operation. Establishing communication systems within the organization, properly training operators and anticipating potential problems resulted in a successful, incident free harvest.

3.3.1 Wet bales

Wet bales are a serious problem. Most damage occurs when they absorb standing water after harvest. Their weight can damage harvesting equipment if moved. In cold weather they freeze together or to the ground. In warm weather they can rapidly spoil. Disposal is a problem, since composting can take years. The best precaution against wet bales is to select the proper site in advance.

Most producers know the areas of the field prone to flooding, slow draining, or standing waters. This information will be necessary if bales are to be staged. Optical illusions will often mislead the human eye when attempting to visually pinpoint the ideal staging location. Staging bales along streams or on the topside of terraces should always be avoided. Some entire fields are at high risk for flooding or standing water. If these fields are to be harvested plans should include immediate removal of bales after baling in order to reduce risk.

Although there is always a risk of bales freezing to the ground none was experienced. However, fields slower to drain would have higher risk. At the plant, stacking on several inches of gravel provides for good drainage, but some gravel will stick to the bales when being moved for processing. This is especially true in winter months. Ground should slope away from stacks.

3.3.2 Fire

Fire, including spontaneous combustion is always a concern when storing organic material that is subject to microbial action. However, storage of all Ag residues should be kept in perspective. Millions of tons of hay and straw, along with some corn stover, are baled each year with relatively few encounters that can actually be traced to spontaneous combustion. The heat created in the bale of corn stalks dissipates more easily than the more densely packed bale of alfalfa hay. The corn stalks are less homogeneous and vary in dimension and composition than the other materials.

Either risk is reduced when fine particles and dirt are kept to a minimum. Fines and dirt reduces the air circulation. The heat created is normally absorbed and exhausted by air circulation.

In the GLCC project some stover was baled at 35% to 45% moisture or higher and no spontaneous combustion occurred. During the '97-'98 crop year DES stored tightly packed square bales inside an improperly vented shed--jammed against each other with no aisles and associated open space. Some bales exceeded 30% moisture and it literally rained inside the building, causing discolored bales, but no spontaneous combustion occurred

In both the GLCC and the DES projects, attempts were made to reduce incidents of cigarette smoking. No smoking signs were posted and employees were warned that if they were caught smoking in areas designated non-smoking they would be fired. Even so, there was evidence that smoking was taking place. Cigarette butts in equipment ashtrays, bale storage areas, and elsewhere were common. It seems as though the urge to smoke often overrides the fear of job loss. At least one fire was attributed to cigarettes.

Some form of spark arrestor was encouraged for exhaust systems of all transport power units. In the DES project one unit was lost to fire attributed to sparks from the semi tractor’s exhaust. Hot bearings and other equipment induced heat sparks caused several fires in both projects. Safety instructions and available means to extinguish fires enabled very minimal and in most situations no damage to equipment.

3.3.3 Rodents

Around corn stover, rodents are more a health threat to workers and others than a source of contamination and yield loss encountered with food grain crops. Since a small amount of grain can be expected with the stover, a control program should be in place before harvest begins. Rodent problems can be kept in check with a combination of continuous control, completely using up the raw material, and cleaning up the area at least once per year.

In the GLCC project bait boxes were put in place and maintained on a weekly basis by (Orkin) a pest control provider. In addition the inventory plan was generally FILO, first in, last out, with complete cleaning of the area in between each inventory turnover.

3.3.4 Safety

Safety was a major concern in both projects. DES held an in house tractor safety course for all equipment operators. Individuals involved in management were reminded about safety in discussions at weekly meetings. Safety glasses were mandatory in the plant. Ear protection and hard hats were also suggested and were available.

The GLCC project included safety meetings with all employees on a regular basis. Hard hats and safety glasses were mandatory in the plant. Fire extinguishers, first aid kits, and ear protection were also available.

3.3.5 Training Needs

Most balers had experience in operating their equipment even though they were not all experienced with corn stalk baling. Training of harvest equipment operators included corn stover baling differences from other crops in addition to equipment maintenance schedules for oil, grease, and air filters.

In the DES project very little sound and sight problem avoidance methods and understanding was ever accomplished. Some of these methods with long-term experience were of minimal advantage in the short time DES was in existence.

In the GLCC project, balers and haulers did benefit from joint cooperation among operators and direct manufacturer involvement. During the first weeks of harvest much new learning occurred specific to corn stover baling. Frequent one-on-one meetings transferred know-how between the Harvest Manager and the custom operators.

Before the 1998-99 harvest a baler and hauler conference was held to address problems and share experiences. Representatives of equipment manufacturers and the equipment were on hand to answer questions and help solve problems. Most involved felt the conference was extremely helpful for the manufacturers as well as the operators.

3.4 Communications and Coordination

More than 200 people were involved to harvest 50,000 acres: 190 equipment operators and tractor drivers, along with 45 truck drivers. Operating cost during harvest is more than $5,000 per hour for all the fixed costs when the crews are dispatched but unable to work due to high moisture of crops in the field. Productive deployment of people and equipment is key for successful harvest. Excellent communication is required for proper coordination of these resources.

3.4.1 Radios

Private band radios worked well for in field communication. In the GLCC project some of the balers worked together in teams and found radios useful especially when running at night. When problems with mesh wrap were occurring one baler could inform the other of problems that were hard to see from the tractor as it is pulling the baler. This reduced the number of mis-wrapped bales or tears occurring. Many breakdowns are easier remedied with two people versus one. Teams and radios also reduce boredom that occurs when individual balers run separately.

In the DES operation a crew boss normally was in charge of several equipment operators. Private band radios were very useful in directing equipment operators and truck drivers. However, these radios are not reliable enough by themselves over distances and the crew boss also carried a cell phone.

3.4.2 Cell Phones

Cell phones were much more dependable than radios for communications between plant traffic managers and equipment operators. Cell phones would have been expensive for in-field communication. The combination worked very well using radios for in field communication and as first choice to the plant. Having cell phones available, as backup was very useful.

3.4.3 Satellite Tracking

The use of global positioning satellites (GPS) was considered. Truckers or equipment operators verifying field entrances and other locations could use a hand held unit. This was to be accomplished by having the purchasing agent take a reading at the designated location and including the coordinates on the commitment map. A hand held GPS unit with accuracy within fifty feet costs around $100.

Another more elaborate GPS system was discussed. This system would have had transmitters on each piece of equipment and been monitored via screen display by the traffic manager. Direction or lack of movement could have been detected and down time for each operator noted. Isoboard, a large particleboard manufacturer near Elie, Manitoba, Canada used this type system in their straw harvest.

3.4.4 Maps

Field maps are important and were used in both projects. These maps were discussed previously in 2.2.1 and 2.4.1. Well drawn maps completed in advance of harvest with details on surrounding crops, street designation and producer concerns will save a lot of time and confusion during the stover harvest.

3.4.5 In Field Chain Of Command

In the GLCC project, contract operators were responsible for completing the harvest in the fields identified in their agreement. The harvest manager monitored each baler contractor’s progress and occasionally gave suggestions on how to improve their operation by incorporating methods of another contractor that appeared to be more successful.

If an individual contractor was falling behind in their harvest, showing little improvement, the harvest manager transferred part of the contracted acres to other operators as they became available.

Working with each baler operator--30 to 40 contacts--in addition to managing haulers and responding to producers concerns placed an enormous initial workload demand on the harvest manager. A more manageable situation was needed. . . and it evolved with DES.

The DES project was structured so that everyone knew the organization and how they fit in--who their boss or leader was and the equipment operation they were responsible for:

- Baler operators were relied on as field bosses. Baler operators monitored moisture and knew when they could operate. They were also aware of excessive dirt and rocks in the windrow and could instruct rake operators to make necessary adjustments.

- Flail operators were sent to the fields in groups with one operator responsible for monitoring necessary settings and overall field neatness.

- The fork truck "squeeze" operators gathering and loading the trucks also worked in a group. A lead operator’s job was to make sure gathering and loading took place in the most ideal areas and informing the traffic manager as to how many more trucks were needed at a field site. The lead squeeze operator also consulted with the baler operator so decisions could be made as to when the first truck should arrive at the field.

When the farmer informed the harvest manager the field was ready, the flailing crew was dispatched. At the same time balers were put on the schedule to start 48 hours later. This helped minimize the potential of losing a flailed field to an impatient farmer's plow. Truck scheduling for loading was not as critical as baling, having 24 to 48 hours to load and transport the baled stover.

CHAPTER 4: HARVEST

4.1 Monitoring

In a large field operation good monitoring is essential to identify exceptions that may be overlooked due to inexperience or oversight. The short harvest time window for completion makes early correction of these problems important for overall success.

4.1.1 Foreign Material

In the GLCC project the only foreign material that caused a concern was dirt. The reasons for excessive dirt were generally traced back to dirt clods left by the producer’s cultivation practices and can be best avoided prior to procurement. As corn stalks are lying on the ground and traveled over by equipment some dirt will stick to the corn stover. Also some root systems are tipped out of the ground by harvest equipment and end up in the bale. Exact amounts were not calculated although it was thought to be in the 2 to 5% range.

In the DES project problems with dirt were similar. DES also had concerns with weeds and on occasion areas of some fields were avoided due to excessive weeds. Some weed types also contributed to additional moisture. Weeds, moisture and dirt are thought to be major factors in deterioration and overall shrinkage.

In addition to stover shrinkage, dirt in the process causes severe equipment wear. Grinders, mills, valves, pipes, conveyors and other associated equipment coming into contact with the dirt fail much sooner, increasing maintenance cost and reducing on-stream operating time. Disposal at the plant site is another cost to be avoided.

4.1.2 Moisture Measurement

In the GLCC project corn stover was purchased on a dry basis. Establishing moisture levels were first attempted with electronic moisture probes and found to be extremely inaccurate for reasons explained in 4.1.3. Drill bit type probes were also tried, but lower parts of the stocks and cobs were pushed out of the way by the probe causing inaccurate sampling.

To more accurately measure moisture a composite sample from three bales was taken from each load. A minimum of three bales was sampled using a chain saw equipped with approximately a two-foot bar and a specially designed dust catching system. Round bales were cut from the side. The composite sample was then taken to the scale house where moisture content was determined using the Koster Hay Moisture Testing System. This system involves weighing out a specific amount of material and completely drying it with the electric drying unit. The dry sample is then placed back on the specially constructed scale that shows directly the percentage of dry matter and moisture.

In the DES system Delmhorst Model FX2000 Hay Moisture Meters were used. These meters have a moisture measurement range of 8 to 40% for hay and stover. Powered by a 9V alkaline battery these meters can accumulate and average up to one hundred readings. The company mentions that there are many variables associated with measuring moisture content (temperature, crop variety and maturity, cutting, climatic conditions, use of preservatives/drying agents, etc.). These variables must be considered when using a moisture meter. The company's address is: Delmhorst Instrument Co., 51 Indian Lane East, P.O. Box 68, Towaco, NJ 07082

4.1.3 Effects of Temperature and Density on Moisture Probes

The Delmhorst Hay Moisture Meters were found to be consistent if the bales were either freshly baled --less than one hour out of the baler-- or fully cured, occurring in two weeks to one month after baling. In between those two periods meter readings would climb up to more than double the actual moisture. Although the cause was not fully understood, it was though to be due to wide moisture differences, i.e. 20% in the top of the stalk and 40% in the bottom. High moisture level causes increased oxidation and thus increases temperature in the bale. Eventually the high moisture areas migrate throughout the bale. When all parts of the bale reach equilibrium the heating stops and bale temperature is nearer to that of the ambient air.

> Example: A bale was tested just out of the baler. Sixteen probes were taken for moisture readings. Moistures ranged from 11 to 36% and averaged 20%. The higher readings were caused when the probe tip would stop in the center of a larger piece of stalk or lower stalk part that indeed carries more moisture. Temperatures were also taken. In the freshly formed bale temperatures were very near ambient air temperature of 66 degrees.

The bale was retested for moisture and temperature every few hours until a peak temperature reading was found. This occurred approximately 48 hours after baling with sixteen readings averaging 149 degrees and 42% moisture. Over the next three weeks moisture and temperature readings gradually came back down until ambient air temperature was again achieved 21 days after baling. At this point moisture migration had occurred.

Sixteen readings indicated 19% moisture with a range of readings from 15 to 20%. The high heat and humidity that occurs in the curing process evidently caused the three weeks in which false readings were recorded. The bale was also weighed at the beginning and again at 21 days. The bale had lost 4 lbs or three tenths of 1%.

4.1.4 Bale Weights

The dry weight bale density is tremendously important to the baling and hauling cost. In the GLCC project all parties involved were paid based on dry tons. Bale density did not affect the producer. Density does affect baling productivity and wrap cost. Each time the baler stops to wrap a bale it takes the same amount of time and wrap regardless of the density of the individual bale.

Baling Cost Example: Wrapping 875 lb bales versus 1,250 lb bales requires an additional 3,000 minutes when producing a total of 3,000 tons during the harvest season. This incremental time could have produced an additional $5,000 in revenue from another 344 tons of baled stover.

The additional 375 lbs per bale also saves 50 cents/bale in wrap cost. For total wrap savings: 3,000 ton divided by 1,250 lbs/bale is $2,400 less wrap cost.

A baling operation producing 3,000 tons per season of 1,250lb bales versus 875lb bales increases revenue 11.5% while decreasing wrap cost by $2,400.

Density also affects transportation costs as shown in the Table 4.1.

TABLE 4.1

HAULING REVENUE & ROUND BALE DENSITY				
Trip Distance, miles	Hauling Payment per Loaded Trip*			
0 -15	$47	$57	$62	$73
16-30	$67	$82	$89	$104
31-50	$88	$107	$117	$136
Bale Weight, Dry Lb.	900	1,100	1,200	1,400
*Normal trailer load is 17 round bales, 6, 6, and 5 bales.				

4.1.5 Load Weights

The most economically efficient load size is not always equivalent to the maximum legal gross weight allowed on the highway. This is demonstrated in Appendix A – Stover Hauling Considerations and Profitability. Regardless if hauling with automated bale pickers or semi and flatbed trailers the maximum allowable weight of bales on the load is important and is the main reason for monitoring the weight of loads.

4.1.6 Field Completion and Clean Ups

Producers seemed to be disturbed about broken bales remaining in the fields after stover harvest crews completed harvest. Spreading out broken bales is difficult for most operators to accomplish due to lack of proper equipment. Burning the broken bales could alleviate the problem, but there is a liability issue regarding fire and smoke becoming out of control and the possibility of causing traffic accidents in addition to negative public perception.

Rebaling the material seems to be the best alternative. However, this increases baler breakdowns and reduces productivity. Rebaling also leaves some of the remaining residue unevenly distributed where the rebaling took place.

Windrows formed, but not removed or spread out due to snow or for some other reason were also a major concern mentioned by producers. Remaining windrows cause problems with equipment in the future producer operations, reduced chemical controls and increased cutworm populations due to the ideal habitat.

A penalty clause was included in the Producer Commitment, Appendix B2 that compensates the producer if it is not removed. It is repeated below in Table 4.2.

TABLE 4.2

GLCC Penalty If Stover Is Not Removed By Agreed Upon Deadline					
Deadline	Apr 1st	Mar 1st	Feb 1st	Jan 1st	Dec 1st
Penalty	$15/acre	$12/acre	$10/acre	$ 8/acre	$ 6/acre

4.1.7 Contractor Performance

Foremost in monitoring contractors is excessive breakage. Higher incidence of breakage indicates the contractor is not applying three full wraps of mesh or in the case of square balers, missing twine due to an unremedied knotting problem. Pickups and flails operated too low to the ground and getting into the dirt is also often the culprit.

Bale density was closely monitored since hauling operators' profitability suffers if the bales were light. Baler operators also incur additional wrap and twine cost. This is especially true for round balers using mesh wrap. Note: See 4.1.4

In the GLCC project, bell shaped or egg shaped bales were difficult to pick up or haul and tend to be more likely to fall off of the loads. Driving diagonally from one side of the windrow to the other is necessary in many cases in order to keep bales in proper form.

In the DES project, when trucks were hired by the hour it was necessary to keep an accurate record of loading and off loading time so trucker performance could be tracked. Bale counts on each load were recorded along with the operator doing the loading. If loads were consistently short of maximum load size the responsible operator was questioned as to the reason. If loads were taking too long to load or off load records would indicate where the problem was and bottlenecks in the system were discovered and remedied.

4.2 Safety Issues

In addition to personal operator safety, safe transportation of large bales on public roads, fire prevention and stable bale sacking are important safety issues.

4.2.1 Payload Containment

Insuring that bales remain on the load is a primary concern. Straps over each row of bales are necessary when bales are positioned lengthwise on the semi trailer. Two straps running from front to back are adequate when square bales are positioned lengthwise across the trailer. The least time consuming method was found to be in using two straps from front to back if properly installed. Most Department of Transportation officers require 4-inch wide straps versus 2.5-inch wide straps.

Automated containment equipment was used in the GLCC project. The loading arm and side rails fold over the load, securing it in place when on the road. Automated bale picker confinement was considered adequate by most Department of Transportation officers although one officer was not sure of compliance. A ticket was issued and not contested by the hauler because of the time and expense involved. Automated containment saves time and in the GLCC experience has a better safety record than securing with straps. At some point a case will need to be made and be presented to the DOT so a ruling can be made.

4.2.2 Field and Transport Fire Protection

Fire extinguishers should be carried on all field and transport equipment. Overheated bearings are the main cause of fires in field operations. One transportation fire was most likely caused by a discarded cigarette from either the operator or a passing motorist. A spark caused one fire from the semi tractor exhaust system. Special exhaust systems are available and contain spark inhibitors or resistors and work well.

4.2.3 Transport Operations

Driving on the shoulder of the road is a perceived courtesy to other motorists and by most farmers when a build up of traffic is forming behind slower moving farm equipment. However, dust is kicked up by the equipment on the shoulder and blown across the roadway and can at times reduce visibility for other motorists. Unknown to many, driving on the shoulder is illegal in Iowa. The State Highway Patrol has issued several tickets and farm equipment operators driving on the shoulder incurred fines.

Roadsides are often rough and occasionally have washed out areas causing damage to equipment. Staying on the road with proper warning devices, such as wide load signs, beacons, flashers, and slow moving vehicle signs is the safest. DES held a special pre-harvest session encouraging safety and reminders were issued often for both field operations and highway movement.

4.2.4 In Bale Yard

Stacking corn stover is different than stacking alfalfa hay. What works best for hay may not work for corn stover. When stacking large square bales it is recommended not to stack over 6 bales high. Round bales are easier to stack. Using a pyramid style seemed more secure. There was not one incident of a round bale stack toppling over.

A good operator using proper stacking techniques can accomplish very stable stacks of square bales. A less experienced operator can make a stable stack of round bales with less effort. More information needs to be gathered on safely stacking large square bales and proper equipment for this operation.

Neither of the operations had fencing around the bale storage area. Fencing is beneficial and necessary in order to maintain safety. Often curious people passing by were noticed in the vicinity of the bales. The bale storage area should not be readily accessible to unauthorized personnel. Fencing the area will also help prevent easy access for children looking for a place to play.

4.3 Harvest Operation and Management

Staying informed, setting priorities and shifting resources to best meet changing circumstances are the basics for managing the harvest operation. Field visits are necessary to gather information. Planning the work, and working the plan within the constraints of time, weather and other constraints is a constant challenge--success is often based on the early preparation completed BEFORE the start of the harvest.

4.3.1 Priority Criterion

One of the most difficult decisions for management is to decide which is more important, maximum quantity or best storage quality. Higher moisture can increase mold and deterioration in storage, but can substantially increase potential time in which harvest can take place. Low allowable moistures shorten the harvest day and results in higher harvest cost per ton.

In the DES project peak production of square bales was around 40 bales/hour/baler. Average production was around 20 bales/hour/baler. Each time the baling operation was started it would take thirty minutes to one hour to get all balers running smoothly. After start up time the number of bales produced per machine per hour sharply increases.

Estimated increase in production per day for each additional % of moisture allowed between 20% and 24% is thirty minutes and increases at a faster rate above 24% moisture. The impact is shown below for October, 1998:

- 54 hours available in 12 days when baling at 20% moisture
- 74 hours available in 16 days when baling at 24% moisture
- 150 hours available in 18 days when baling at 30% moisture

Although more moldy bales occur in bales averaging 24% moisture, shrinkage or deterioration was not as severe. When used within a week of harvest, bales containing moistures of 30% or more created no major problems in the GLCC project. The winter temperatures also reduced oxidation if bales were allowed to cure before stacking.

In the GLCC project some bales were harvested over 35% in moisture. Many of these bales were placed in single stacks. Heat emitting from the stack was noticed all winter.

Corn plants sprouted and grew on top of the stacks in the middle of winter. Although the plants were frosted they still survived. When the bales were finally moved for processing, nearly 18 months later, some heat still existed. Some of the stover was brown (the color of coffee grounds), extremely dry, and crumbled in your hand. Even with this apparent extreme oxidation and heat no black ash was found.

4.3.2 Grower Field Availability

Often producers neglected to call in and report immediately when grain harvest had been completed and ready for the stover harvest. Better communication as to field availability needs to be accomplished. This is especially true early in the season when harvest crews are idle and there is no backlog of fields ready for stover harvest. Once underway, the backlog of available fields builds and they are scheduled for harvest based on priorities based on a combination of factors including producer instructions, soil type, location, weather and crop conditions.

4.3.3 Baler Maintenance and Operating Time

Most often there was plenty of time for routine maintenance before the dew was off in the morning or when rain had stopped the harvest operation. However, on occasion a problem was discovered or occurred during the period that harvest could be taking place. The harvest continued even if the bales were one or two twines short or the flails were missing a few knives.

Each day harvest began it would take the first hour or so to get the balers running smoothly as it seemed the precision mechanical parts needed to re-polish themselves before the baler would become dependable. An hour can be a large percentage of the baling day when trying to harvest at 18% moisture. These daily restart problems were far less for the round balers.

4.3.4 Grower Harvest Metrics

When purchasing the stover some consideration should be placed on the expected harvest date. Some soils warm quicker in the spring or more ideal weather may allow planting to occur earlier in one area than another. This along with differing maturities of hybrids should be considered.

In both operations there were areas in the harvest circle that were normally 2 weeks or more ahead of other areas. Knowing this allows starting the harvest earlier, which allows a tremendous advantage. Larger river bottoms and sandy soils often are responsible.

Another option that was available in the GLCC harvest was popcorn that is often drier and harvested much earlier than the average field corn. Producers harvesting high moisture grain or earlage can also improve harvest success because this practice also allows an earlier harvest access.

Producers involved in no-till or not planning fall tillage can be of great benefit later in the harvest season. They often prefer to have harvest operations taking place later after the ground is frozen and are the only possible option in an early spring harvest. Having a variety of types of fields involved and fields that drain quickly, such as coarse sand or the Loess type soils similar to those available around Harlan can be helpful.

4.3.5 Quality Control

The DES Harvest Manager routinely inspected bales in the field for moisture and dirt. The electronic moisture tester is fairly accurate if bales are freshly baled. Low moisture was extremely important in the DES operation. Bales exceeding moisture limits were discarded and taken to the compost site at a considerable cost to DES. Bales containing excessive dirt or root systems were also discarded, as they tended to cause discoloration. Both dirt and moisture increase oxidation during storage, which was the main cause of discoloring. Quick response in keeping these problems under control is important.

In the GLCC operation, the Harvest Manager primarily monitored bale density and wrap cost, although there were concerns with dirt and moisture. Novice corn stover balers required more assistance, resulting in more emphasis on bale density and reducing raw material and hauling cost.

4.3.6 Weather Monitoring

Local weather information was continually monitored with a DTN system provided by Data Transmission Network Corporation. Monitoring approaching storm fronts was especially important in the DES project and somewhat effective in minimizing excessive windrow production. The DTN was also helpful in identifying how wide spread rain was and where dry areas could be found so harvest could continue. The rainfall amount was also monitored at many locations to identify where restart would most likely occur first.

4.3.7 Field Access

Field access was checked by the Harvest Manager to make sure that it was available before harvest equipment was dispatched. Occasionally, the original choice for entering the field was not available because the field closest to the entrance had been chisel plowed or had not yet been harvested.

4.3.8 Resource Scheduling

For DES baling operations there was not enough personnel to cover all of the equipment needs and the available personnel were shifted where needed. For example, If rain was not an immediate threat to bales left in the field then some or all loading and staging operations were put on hold to insure that windrow preparation and baling operations had adequate man power. Visa versa if rain was threatening. Flailing, possibly raking and even baling was stopped to maximize the number of bales moved into storage prior to the rain.

4.3.9 Contingency Plans

The contingency plan for DES included two different approaches. One approach included moving operations or contracting with balers in the high plains, western Nebraska, western Kansas, and eastern Colorado where the humidity is less of a problem. Even if snow fell it will normally melt and evaporate giving additional late season harvest opportunities. If a spring harvest has to take place in the high plains, lower humidity and slow stalk deterioration has the best chance of meeting necessary color and quality standards set by DES.

The second plan included bringing 27 smaller 3'X 3'X 8' balers into the operation within 150 miles of Sharon, Wisconsin. These balers were ready and could have commenced operation as soon as notified if weather permitted.

GLCC contingency plans include a local spring harvest, as color quality was not as important as in the DES harvest. Far less stover is available in a spring harvest. However if more raw material was needed a spring harvest could take place. The harvest area may need to be expanded with rising transportation cost. The use of soybean stubble and mature grass hay harvested before corn stover the following summer and early fall were also possibilities although furfural potentials would have been lower.

4.3.10 Baler Service and Support

Assuring that replacement parts are available for the equipment at all times should not be overlooked. Many times balers break down during the night or on the weekend. In the GLCC project some balers that had not kept a supply of the more predictable replacement parts on hand were forced to shut down (3 days over the Thanksgiving holiday) until the part store or implement dealer opened for business.

Other baler operators thought ahead, insuring they had a wide assortment of spare parts readily available.

Some implement dealers opened at any time in order to accommodate baler operators. The baler operators were given a list of the names and phone numbers of dealerships that were most accommodating.

Other baler operators shared a common and complete replacement part supply. The parts and tools necessary for repairs were kept on a service truck that was readily available in the fieldwork site.

In the DES project an extensive part room was maintained at the plant. A one-day training course was provided to all baler operators. A Heston Baler Technician reviewed the entire baling process with special emphasis given on trouble shooting and preventative maintenance.

CHAPTER 5: STORAGE SITE & INVENTORY MANAGEMENT

5.1 Storage Site Selection

5.1.1 Collection Radius

A large collection radius offers more flexibility in assigning harvest equipment and improves equipment utilization. If fields are wet in one area, another area may be dry and can be harvested. Similarly, if wet weather is threatening in one portion, equipment can be assigned to another section. More importantly, the larger radius better insured the desired quantity of material was obtained.

The collection radius was economically limited to 30 to 50 miles for the GLCC operation even though some stover was harvested up to 100 miles away. GLCC paid the same price per bale regardless of distance. The farther from the collection point the more the hauler received, which in turn meant less for the producer. Beyond 50 miles, the producer received less than $10/acre for the corn stover. This amount was too small for most producers to commit to a new program.

Intermediate collection points were arranged with many producers located 20 miles or more from the plant at the time of procurement. Their bales could be staged near the entrance to the field for later movement. If movement of the staged bales occurred after normal planting the producer would be compensated in the amount of current cash rent value of the property involved. The producers' main concerns with temporary storage were losses resulting from bail breakage, shrinkage in storage and risk of fire and vandalism.

None of these intermediate sites were used. As long as it appeared that haulers could get the stover off the fields and delivered to the plant before the spring thaw, there was no point in implementing off site collection points and incurring unnecessary costs.

DES took a different approach, leasing storage buildings from producers at locations other than the processing plant. Stover gathered near these sites incurred additional transportation costs since nearly half of the stored stover traveled away from the DES processing plant to the storage site only to retrace some of the same route when returning to the plant.

5.1.2 Site Requirements

A plan for an off site collection point includes selection of a well drained piece of ground with a sod base large enough for placing large round bales in single rows. Later this will allow movement without having to deal with out of shape bales that result from stacking several rows high. The off site collection point should be in close proximity to several fields containing bales.

A well drained, as well as fast draining site for bale storage is absolutely imperative. Without it, deterioration of lower bales caused by water collecting under or against the stacks will cause shrinkage as well as the stacks to become unstable. Operation of equipment becomes difficult if the site is not well drained. In the GLCC project, harvest delays occurred because of the poor drainage. Also problems were encountered when retrieving the bales for processing.

Moving round bales after storage can be difficult while trying to stay within the legal maximum load width and highway transport should be avoided. Also, bale breakage does occur when handling and is expensive to retrieve since it is no longer in the denser bale form. For these reasons storage sites within close proximity of the plant are best.

5.1.3 Desired Infrastructure

All of the desired infrastructure may not be available at any particular site.

- A well-drained and quick draining graveled site or a large hard surfaced site.
- Away from population centers.
- Located in low traffic area with wide roads and stable shoulders.
- Close to processing plant to minimize handling cost.
- Wet storage bunkers so moisture could be added and stover stored at 50% moisture.
- High corn production area in terms of yields per acre and total acres.
- Conventional corn production not ridged or furrow irrigated, to facilitate baling.
- Low rainfall area and low humidity.
- Consistently early fall harvest of corn in the area.

5.2 Storage Site Drainage

5.2.1 Gravel

DES selected a ten-acre area for composting spent horse bedding that was returned from their customers. Part of the site was available for stacking bales. Small one inch crushed limestone six inches deep was applied to this area and it drained well. However, when bales are moved into the processing plant some gravel is carried along, causing additional equipment wear.

Six inches of gravel did not result in enough compaction to support the bale handling equipment. In the process of stacking bales, the telescopic boom truck would occasionally dig tracks in the surface when it extended to place a bale high on the stack. The uneven surface caused problems with equipment movement. Frequent maintenance to remove the ruts is helpful. A garden rake is adequate for most situations.

5.2.2 Dirt

A dirt surface is more difficult to maintain and keep free of ruts, but it is more forgiving than a gravel surface since it better absorbs the shock when ruts are crossed with heavy equipment. If bales are stacked on dirt, consideration should be given to the type of soil at the location. Some types of soil drain well while others do not.

The soil at the Harlan site did not drain well. Equipment traffic caused severe ruts that were an enormous problem. Occasionally, the plant would close to raw material delivery because of the problems with mud. In cold weather any ruts would freeze solid, also impeding operations.

5.2.3 Paved Surfaces

GLCC had no paved surfaces on the building exterior. DES had the entrance roads and parking lots paved, and all storage was inside, on a concrete surface.

Maintaining a smooth surface is safer and work is more easily accomplished. A paved surface allows maneuvering with equipment regardless of weather. Gravel and dirt sticking to the bottom of the bales is also avoided. Sloping the surface to enable drainage is important.

5.3 Environmental Concerns

5.3.1 Run Off

Run off from stacks of baled stover is not thought to be a major concern. Untarped bales tend to absorb rainfall only to release most of the water through evaporation during drier periods. In the case of tarped bales, the water does not travel through the baled stover and no harmful amounts of water-soluble phosphorus, potassium, or nitrates are expected in any water running off of the storage site. However, no tests were made to validate these assumptions.

5.3.2 DNR Regulations

Potential runoff from bale storage yards was not of concern to either the Iowa or Wisconsin Department of Natural Resources. The bale storage yards were considered to be agricultural in nature, and not regulated as a point discharge source.

In the DES project, 7,000 large square bales rejected from the previous harvest was taken to an outside storage site adjacent to the spent horse bedding returned from the customers. These rejected bales were either moldy or discolored and did not meet quality specifications. The composting site for the spent horse bedding that contained manure was monitored as a point discharge, requiring a permit by the WI DNR, but there was no permit required for the bale run off.

5.3.3 Mold Spores

Bales have been stored and used on the farm for livestock bedding or deteriorated in Iowa cornfields for years. The Omaha GLCC Plant maintained a huge pile of corncobs on the riverfront between the cities of Omaha and Council Bluffs. Neither situation raised any concern from adjacent parties.

This was not originally an issue or even considered as a potential problem in the GLCC project. Whether founded or unfounded, mold spores did become a concern of some residents in the community. They asked if mold spores could blow from the large bale stacks into the City of Harlan (less than one mile to the north) and cause health problems. To address the questions posed by those who have concerns discussions with industrial hygienists and toxicologists might be appropriate, and a sampling program may be considered.

In the DES project, mold was a major concern as it related to the health of the valuable horses that used it for bedding. Also, mold or the conditions allowing its growth caused the bedding to become discolored.

5.3.4 Fire and Smoke (Roadways and Population Centers)

In the case of accidental fire there is a safety concern for firefighters and others involved. Mowing frequently controls grass and weeds around the bale yard, reducing the chance of fire entering the facility.

All smoking on the site was prohibited. Any fires, such as welding, were done with a permit, with full precautions taken to prevent any accidental ignition.

If some of the larger stacks catch on fire, smoke could linger for days. The main concern in this case is restricting visibility for nearby traffic. In both projects the main bale storage was located within city limits. Smoke could also cause evacuation in these population centers.

Burning broken bales in the field was considered too risky in most cases. An uncontrolled fire can affect traffic and cause other damage to people, property and the environment. However, some producers along the Missouri River bottom held little concern for this, as it is still common to burn stover off entire fields in the fall of the year.

5.3.5 Insects and Rodents

Insects, such as European corn borer, live and over winter in the corn stalks in the Northern Corn Belt. Some of the producers near the GLCC collection point were concerned as to whether or not these large stacks of corn stalk bales might cause nearby cornfields to be at higher risk.

To answer the question some of the baled stover was inspected for borers, and they were dead--attributed to the heat produced inside the bale during the curing process. No producer in the vicinity of the GLCC plant reported problems with production in the following growing season.

Early rodent control practices were in place at GLCC to minimize the potential of large rat and mice populations. It was thought the rodent population would be easier to control in the stover than when ear corn is stored in wooden cribs on most producers' farms since there is little corn in the stover.

Using a professional extermination and pest control service and thoroughly cleaning up stover after storage has minimized the problem.

5.3.6 Restricting the Area (Appealing Play Ground)

Insuring storage areas were restricted was overlooked in both projects. Efforts should be made to reduce access to the storage area. A fence around the site should be considered. Children are attracted to any environment that provides the chance to explore. Serious injury could incur if anyone were to fall off of a stack or if a stack collapses on him or her. Although the incidents of unauthorized people in the storage areas at both projects were relatively few and no injuries or mishaps encountered, only one accident could have been devastating.

5.3.7 Public Perception

A collection site is best located away from a major highway and population centers. In Harlan, GLCC collection stirred much curiosity during the harvest. As the stack of bales grew, so did the public's curiosity. This was a unique, new venture. Large scale collection had not been done before in this area. Most were amazed with the size of the storage area and the large amount of bales it contained. Many asked "why?" and "what for". In this case, earlier communication may have avoided the surprise that initially drew unwanted attention.

By the following summer the size of the storage area remained relatively unchanged. Progress in processing appeared minimal and bale deterioration was evident. The public concerns grew to include the possibility of mold spores and rodents moving into town. Also, the overall appearance was less appealing as the bales aged and the storage area showed a lot of signs of "active" work.

Perhaps the evidence of more progress occurring in processing would have lessened the negative perception. Also, overall housekeeping must be kept at a high level--and is difficult to achieve day-in, day-out under varying weather and operating conditions.

5.3.8 Tramp Stover and Dust

In the DES project, storage buildings were located very near residents. During any movement of corn stover bales there is a certain amount of leakage. This constant leakage blowing onto nearby lawns was a source of frustration to those nearby residents.

Leakage from loads of corn stover being transported through towns was also a source of public frustration. Wrapping the round bales with netting alleviated some of the tramp problem. Transporting these bales with just string resulted in some of them breaking apart entirely along the roadway--causing an unacceptable and dangerous situation.

5.4 Scales and Weights

5.4.1 Type Consideration

An electronic scale with a flat approach and a 75 ' platform is best. The maximum legal length for tractor-trailer combinations in Iowa is 75'. Locating the sampling operation and a load print out at the scale can reduce the turn-around time for drivers.

In order for over the road semi-tractors to pull the maximum weight, they will need to use longer trailers up to 53’ or they may opt to pull what is often referred to as B trains (two trailers pulled in tandem). Another way to achieve area on the trailer for maximum weight is by using what is called a double drop deck. This type of trailer has a small road to trailer clearance so entrances to the scales should be sloped gradually. A computerized electronic scale is faster than a beam style scale. It also provides an integral record of the transactions that can be used for inventory control and should be selected.

5.4.2 Scale Time and Staffing

Although time spent on the scale is often thought to be insignificant it should not be overlooked. During the average 20 hour day a JCB unit might deliver 11 loads with a 7.5 minute scale time (3.75 minutes each way – part of this time included the walk to and from the scale house to retrieve the ticket). 7.5 minutes X 11 loads = 82.5 minutes/day and about as many dollars in lost revenue.

Eliminating the scale wait time at GLCC has the potential to increase gross income about 7% and an increase of far greater proportion in net income for the JCB owners.

GLCC found it difficult to keep the scale manned, since loads were coming in around the clock with occasionally more than a half an hour period between loads. This absence of manpower lengthened the turnaround time significantly. It was decided that JCB drivers would weigh their own loads. This helped, but did not allow average scale times to fall below 7.5 minutes.

Stover can be purchased successfully by the bale as in the DES operation, which would eliminate scale time. However, for most companies, purchasing corn stover by the bale may not be a workable solution. Understanding and being considerate of the economic effects is best for all involved. Keeping the scale turnaround time to a minimum is required.

5.4.3 No Scale

In the DES project, as previously mentioned, a scale was not routinely used. Stover was purchased by the bale. Although DES had a good idea what an average bale would weigh, variances caused by different hybrids, field conditions and baler operators were experienced when weights were checked at a nearby grain elevator scale. These check weights often revealed a 25% variation. The most apparent reason for this was the different baler operators. Probably the least accurate method of buying stover is by the acre, as tremendous differences can occur in different years, different hybrids, and many other reasons.

5.5 Methods of Stacking or Piling

5.5.1 Square Bales

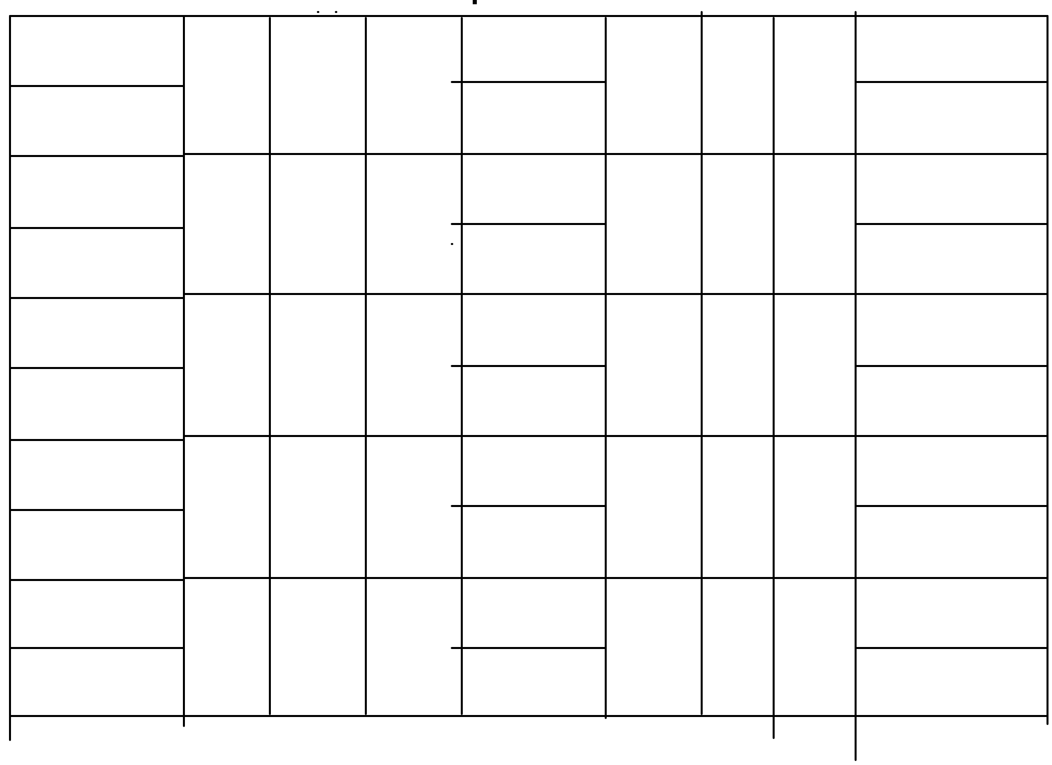
A diagram of a method of stacking large square bales believed to be the safest can be found on the next page. This method is ideal when stacking large square bales outside, but might not always be practical when storing inside, as later discussed in section 5.5.4. However, outside storage is most likely the only practical option when considering ethanol or another energy application. For this reason discussion in this section will only relate to the outside stacking method depicted.

Placing loose stover along all outside edges of the square bale stacks accomplishes two things. First, it helps to lean the bales into each other making the stack more secure. Second, it helps protect the lower outside perimeter of bales from the deterioration caused by rainwater coming off the tarped stacks.

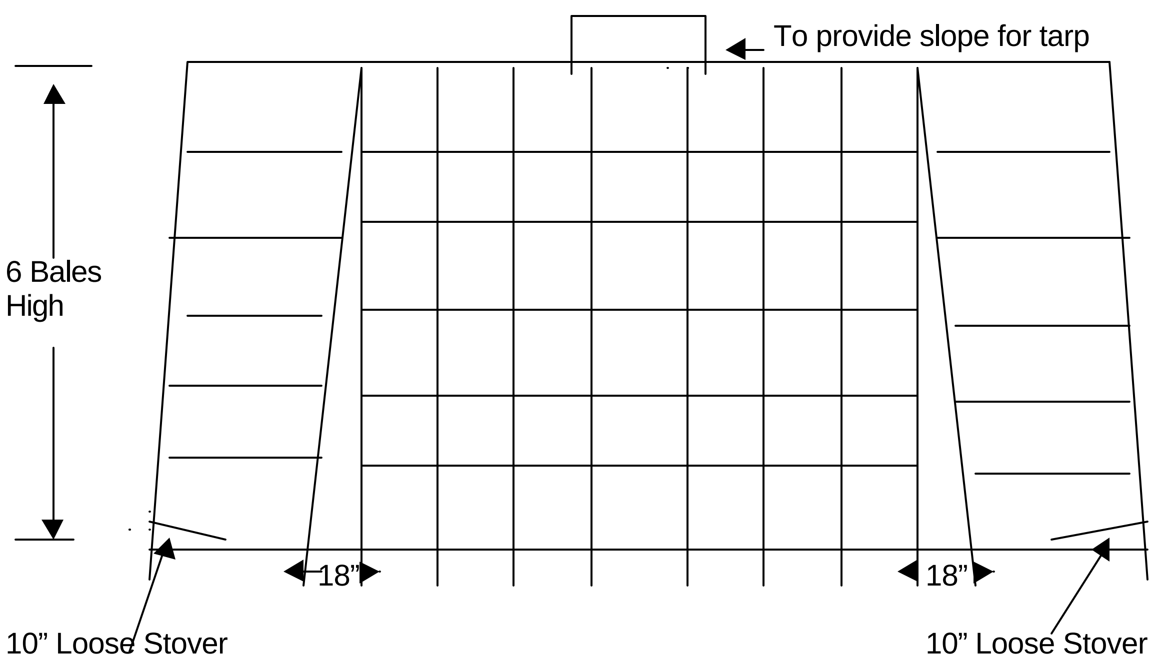
The lower 18” space between the outside row of bales and the bales that make up the interior of the stack helps insure that outside bales will continue to lean toward the inside even if interior bales settle and try to lean outward. The single row of bales on top of the stack creates a roof type slope and provides for air movement under the tarp.

Recommended Square Bale Stacking Plan

Top View



Front View

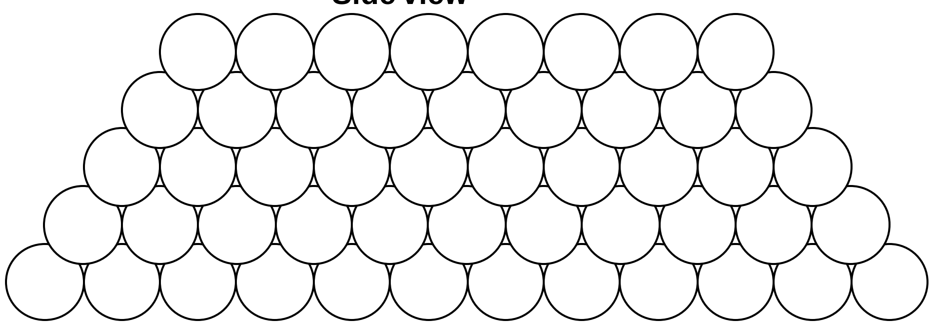


5.5.2 Round Bales

In both projects experience with the equipment available in the stacking operations for square and round bales indicated that it takes less time and experience to achieve a similarly stable stack of round bales versus square bales. Round bales stacked in a pyramid shape proved to be very stable. Because of the overall weight and telescopic ability of stacking units, a limit was set to only stack 5 bales high. The round bale stacking equipment would pull in and place the bale when resistance of the bale behind on the preceding stack was felt. The bale was lowered and the stacking unit would retreat. The newly placed bale would then self adjust and settle into and between the saddle formed by the opposing curves of the two bales below it.

Recommended Round Bale Stacking Plan

Side view



A small additional amount of time to stack each bale would be required as height or number of tears in the stack was increased, but could have easily been accomplished with heavier telescoping equipment. Note: If storing at remote locations requiring later transport to the plant, considerations should be given for oblong bales that could occur when bales are placed on a stack in extended storage. An alternative option would be single rows of bales, which are more likely to hold their shape if space between rows is maintained. It would be best if bales were placed on gravel or well drained soil so deterioration of the bottom of the bale is minimized.

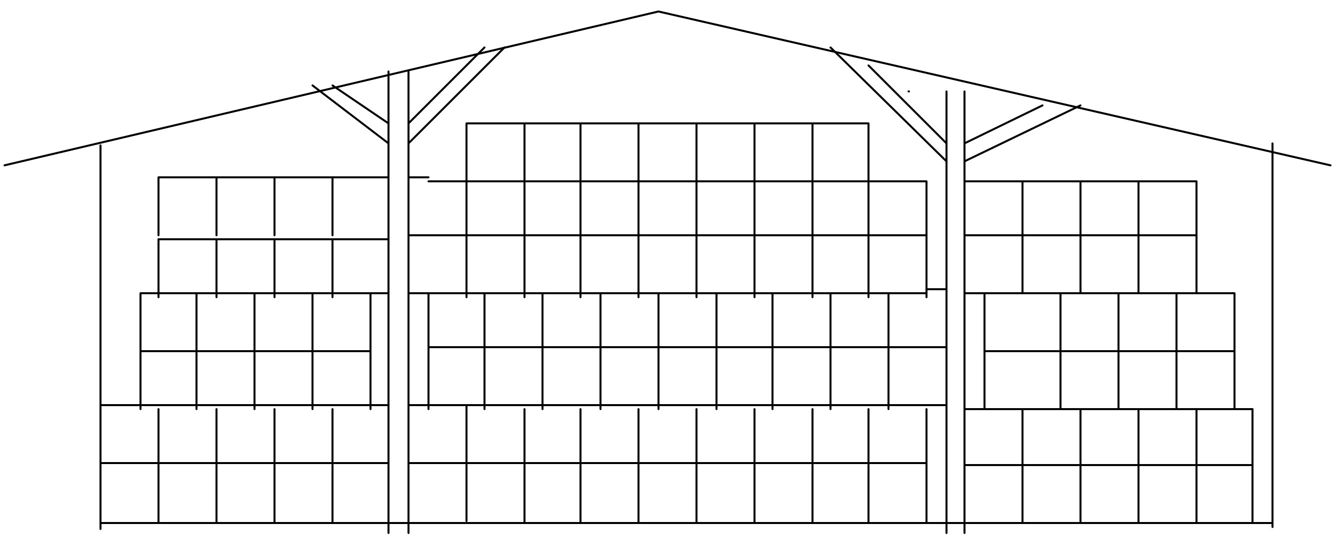
5.5.3 Bulk Materials (Silage Model)

Although stacking in the bulk for storage purposes did not occur in either project it was considered. Overlooking bulk storage was mainly due to the fact that the most practical method of harvest in the immediate future appeared to be in bale form. GLCC encouraged consideration of other options and the following method was thought to warrant exploration: Harvesting in the bulk at a higher moisture, right behind the combine, then grinding and adding additional water at the storage site bringing the average moisture to 50% could have positive effects. Silage has been stored in this manner for decades.

Stover could be packed in a bunker silo achieving wet weights near 50 lbs per cubic foot, similar to the methods used by large cattle feedlots for corn silage. Positive results might be reduced risk of spontaneous combustion, higher density in storage, less storage area, affordability of a hard surface storage area, higher stacking with less risk of mishap, easier access, easier control of rodents and less cost of stacking and stack management.

5.5.4 Inside Storage

In order to maximize space of inside storage, normal stacking, such as suggested in 4.2.4, may not be practical. This is most often true because stacks cannot be approached from all sides. Walls of the storage structures in the DES project were made of tin and were not able to tolerate much pressure from leaning bales, nor were the roof support poles. The safest and most secure method of stacking was again lengthwise toward the stack with a stair step method of stacking near the walls. When stacking or unstacking bales near the roof support poles, efforts were made to keep the same amount of bales on both sides. Hopefully, this would equalize or support side pressure. Many hollow areas were evident around support poles.



5.5.5 Risk to Employees

Maintaining stack stability is important need when stacking, during storage and when disassembling the stack. Bale movement continues even after it has been placed on the stack. Settling first begins at this point and continues until the bales are moved for processing. If bales are soft or improperly stacked, the settling effects cause the stack to lean or move. This movement is gradual and not easily apparent. Workers may get a false sense of security. Once the bales are past the center of balance, the movement is faster and can be seen, but still might not be noticed until heard hitting the ground. Being taken by surprise by falling bales is a real possibility.

While settling stacks of square bales, especially low density bales, can topple over the long way (end over end versus side over side) as well as side ways. Potentially, the most secure stack for square bales would be similar to that described in 4.2.4.

CHAPTER 6: TRANSPORT FROM STORAGE TO PROCESSING PLANT

6.1 Cost Control

6.1.1 Loading Cycle

Two types of equipment were used: Conventional tractor-trailers and a self loading wagon pulled by a versatile JCB tractor that could operate in the field without difficulty and safely travel at 45 MPH on ht highway with a full load. The former required a crew to load and unload the cargo, while the latter could be loaded and unloaded by the driver.

The loading and unloading of the trailer with bales can be labor intensive and time consuming. This time should be minimal, since their charge continues to accumulate regardless. Without close controls, cost can spiral up rapidly. In the DES project, two telescopic loaders were used simultaneously to shorten trailer loading times. Both loading and off loading times were usually satisfactory. Loading in the field often took less than ten minutes. At the storage site off loading times were normally below seven minutes.

At times bottlenecks occurred. An effort to reduce these costly bottlenecks was in place, but not always effective. Efforts included bringing trucks on duty at different times rather than all at the same time.

In the GLCC project, one man operating an automated bale-picking trailer was often able to load bales in the field in less than twenty minutes and with some modifications now are consistently below fifteen minutes.

With automated systems far less bottlenecks occurred. One operator consistently working is definitely an advantage versus loaders waiting for truckers, truckers waiting to be loaded or waiting to be off loaded, traffic managers trying to coordinate, and crews gathering bales only to sit them back down for loading crews to later pick up and load.

6.1.2 Highway Speed and Overall Efficiency

Trucks were capable of faster speeds on the highway, averaging 52 mph while the JCB averaged around 38 mph. In the GLCC project, a comparison of the travel speed of trucks versus the JCB units was made by IHCF. For a 70 mile round trip with identical loads the JCB had a 45 second per mile disadvantage, 52 minutes longer in transit. However, the ease of loading and unloading JCB tractors resulted in less overall cost since they averaged considerably better timing in field loading and suffered fewer mishaps in the field.

6.1.3 Load Weight

The total load weight needs to be maximized. However, consideration of other possible constraints is needed: the maximum tons moved per man per day or per piece of equipment per day.

Field compaction-- pounds per square inch in terms of tire to soil contact--.is another factor that should be minimal. It can reduce the next crops yield. A semi-trailer grossing 80,000 lbs carries an unacceptable pressure per unit of soil surface. Special tires that spread the weight over more surface area are available. They must be run at a slower highway speed to reduce heat build-up, so trade offs must be evaluated.

The farther the distance traveled with the load, the more important it becomes to carry maximum load weights. Appendix A “Stover Hauling Consideration and Profitability” contains additional information.

6.2 Regulatory Issues

6.2.1 License

A Commercial Driver License (CDL) is required in Iowa for drivers of trucks and over the road tractor-trailers hauling over 26,000 lbs. Requirements also include drivers be over 21 years of age, carry a medical card, have travel authority, proof of insurance, and possess a wide load permit, and so on.

The numerous DOT regulations at times enforced by overly zealous law officer makes over the road trucking a stressful occupation for many of the operators now. Attracting quality drivers to pilot loads of a new and readily obvious load is viewed as especially difficult. For example, if a corn stalk works loose from a bale during transit and extends beyond the legal width or height, the operator is in violation. A court appearance may be required, and a fine in the hundreds of dollars can be expected.

Implements of husbandry involve far less regulations. These are generally defined as all vehicles designed for agricultural purposes and exclusively used by the owner in the conduct of the owner's agricultural operations. There is no logbook to maintain; axle and width limits do not exist. Neither driver's license nor medical card is required. As a result, good drivers are more available and easier to keep when working under the latter requirements.

6.2.2 Insurance

Implements of husbandry can normally be insured under the farm policy umbrella. Insuring a fleet of trucks is much more expensive in comparison. Savings in insurance premiums for IHCF exceed 25 cents/ton hauled--equivalent to $2.50 per trip. This accumulates to $25/day average, easily approaching $1,000 per vehicle insurance savings over the corn stover harvest.

6.2.3 Speed

Legal traffic speed in Iowa is 55 mph on standard highways and 65 mph on the Interstate. The legal speed for implements of husbandry, including JCB units, was 30 mph--even though they were fully capable of safely traveling at 80 KM/HR, 48 MPH with a full load. The Iowa legislature was asked to increase the legal speed for implements of husbandry. The argument was made that travel speeds nearer that of the average traffic flow is safer if implements are properly equipped. In the deliberation it was determined not all tractors could negotiate this higher speed safely. . . but the legislature did increase the limit by 5MPH and Iowa law now permits implements of husbandry to travel up to 35 mph legally.

6.2.4 Length

Truck length is important when choosing specialized equipment for moving bales and when contracting with haulers from other areas than Iowa. The legal length of a single vehicle in Iowa is 40'. Originally, Iron Horse Custom Farming (IHCF) planned to use automated bale picking units similar to those pictured in Figures 1 and 2, but mounted on a truck bed rather than pulling a trailer as depicted. A single unit has better traction in the field, are easier to operate, and are less expensive to purchase. The reason these units were not used is because their overall length was a few inches over 40'.

The truck with the special bed was not in compliance with Iowa DOT laws and special permits were not available. Even though these units were used in most western states and in Canada, they were not legal in Iowa. This limited GLCC's ability to contract with haulers who already had these truck mounted units. The units also carried loads higher making it difficult to stay under the legal height limit in Iowa of 13'6".

Other disadvantages exist in Iowa as well as other midwestern states. DOT laws need to be examined before purchasing equipment or contracting for hauling with new haulers. Check to see that axles are at least 40" apart, but not more than 8' apart. Axles closer than 40" apart are restricted to legal weight of one axle.

These were not issues when JCB units were used because JCB powered units fell under implements of husbandry laws and were exempt from many laws imposed on trucks.

6.2.5 Operation Hours

In the GLCC project, stover harvesting was planned to take place round the clock – 24 hours a day. Hauling a wide load of large round bales had to occur during the day when conventional over the road semi trucks were used. The custom operated JCB (a farm type tractor) was originally restricted also. The legislature was again asked to review and make changes that would allow farm tractor night travel with wide loads. The changes now allow the stover harvest hauling operations to continue during nighttime hours while using implements of husbandry.

It might be important to note that this change in the law only covers farmers and customer operators using implements of husbandry while traveling from the farm to the processing plant and may not cover situations where movement of stover is from a company owned or controlled storage site to the plant.

6.3 Problems to Consider

6.3.1 Mud

If the bales are stacked on dry ground during the fall harvest season the ground under them will be dry when moving them to the plant even in the spring. The reverse is also true. Some of the bales in the GLCC project were moved over one year after being stacking on wet frozen ground.

When these bales were moved for processing in the month of July (when the ground is normally firm even if it had recently received rain), the ground was very soft and muddy--unlike nearby ground where there was no stack. Areas that had no stacks were firm even when wet. Why the soil under the bales was so soft is not totally clear.

Moving these bales to the plant was extremely difficult as equipment became mired in the mud, just as if it was following a spring thaw. It is also unclear if gravel under the bales would have solved this soft, early spring-like condition.

6.3.2 Ruts

When stacking or removing bales in the bale yard, ruts caused by equipment movement should be routinely graded level. Water from rain or thawing snow will often fill ruts and make them more difficult to work level later. These ruts can also lead water back to the stacking area. Even small ruts made during a warm winter afternoon can become a problem as they freeze when temperatures drop during the night. These wintertime ruts can be very hard on equipment and it may be several days or even weeks before the thawing of frozen ground gives another opportunity to repair them.

6.3.3 Snow

Snow did cause problems at times making surfaces slippery, but this was not a major problem. However, plans should be made to deal with the large volumes of snow that can occur. Fire lanes between stacks could fill in after a major snowstorm. Some consideration should be given as to how and what direction the snow will be moved in order to gain access to bales. Most of the snow will blow off the tops of the stacks. This is especially true with square bales.

6.3.4 Bale Distortion

After a large round bale has been in storage with other bales stacked on top, it will tend to change its’ shape. The severity of this change and shape is determined by bale density, weight of upper bales, length of time stored in the stack, moisture content, and space between stored bales. A dry dense bale placed in a tight stack for a few months will distort far less than a bale in storage for a year carrying high moisture. This distortion can make it difficult to transport from storage to processing. Particularly if there is a need to travel on public roads, these distorted bales will not load or be contained as easily. If travel on public roads is necessary it might be best not to stack bales, but rather place them in single rows at the storage site.

6.3.5 Breakage

Each time bales are handled some breakage will occur. This loose material will lose the density that it had in the bale form making it more costly to load and transport to the processing plant. This is especially true if the bales are transported a long distance.

The longer bales are in storage the higher the percentage of breakage. The sun gradually breaks down the wrap on large round bales and rodents will gnaw through some of the twine on the square bales. Another problem is how much deterioration has occurred. Grinding at the storage site and pneumatically transferring stover from storage to processing would be a large advantage.

CHAPTER 7. EQUIPMENT PERFORMANCE

7.1 Rakes

Raking the field increases the amount collected. It can also add cost and increase foreign materials in the bales. With a windrow left by the combine, raking is optional. If a rake is mounted on the tractor pulling the baler or in front of the baler itself, the raking and baling operations can be combined.

7.1.1 One Pass Raking and Baling

In the GLCC project, the combine already formed a windrow. They varied in size for several reasons including combine head size (number of rows), corn hybrids, combine operators, and type of combine.

When gathering more stover was necessary for productivity or desired by the producer, wheel rakes were mounted on the front of balers or on the front of tractors pulling the balers. These rakes normally consisted of a pair of rake wheels on each side of an already existing windrow and collected an additional 20 inches of stover on each side of the windrow. A two- wheel rake mounted on the tractor retails for $2,200.

No additional personnel and a minimum of additional equipment were needed. These rakes also provide easier control of the amount of stover harvested within fields of changing topography. Mounted rakes could be hydraulically raised or lowered depending on the slope in that immediate area allowing more or less stover to be harvested.

7.1.2 Wheel Rakes (V formation)

The DES project did not require the combine to leave a windrow and raking was required. A wheel rake that had an adjustable V (pictured in Figure 7) was the primary method of forming a windrow. In the GLCC project, large square baler operators also preferred this type of rake for increasing productivity.

The rake requires an additional man and a power unit, most often a tractor, possibly a pickup. The rakes have seven wheels gathering stover on each side of the windrow that is formed in the center of the fourteen wheels positioned in a V formation. The maximum working area of the V rake was over 28 feet. The rake working area could be reduced according to the size of the desired windrow. Also, the rake height is hydraulically controlled. Their list price is $6,500--$7,000.

7.1.3 Dirt and Rocks

Excessive inclusion of dirt and rocks result if the rakes are set too low or when the root systems are raked into the windrow. The latter occurs when the rake tines pull out the "crown" with the root attached. The crown is the very bottom part of the stalk. When harvesting grain the combine leaves the lowest, most rigid part of the stalk uncrimped and standing. In especially soft or sandy soils, or when rootworms are present, the tine on the rake wheel hitting the crown can dislodge about a six-inch diameter by two-inch thick root that holds much dirt. The raking process rolls this root with most of the dirt intact into the windrow.

Under some field conditions excessive dirt is difficult to avoid when attempting to harvest the stover. More control is exercised when a flail chopper is used prior to raking. The chopper cuts the stalk about four inches above the crown, leaving it anchored in the soil. With the stalks cut off, it is easier for the raking operator to control the height and avoid pulling out the crown and the roots. The flail can cause the same root systems to exist in the windrow if improperly adjusted. The flail's RPM, ground speed, cutting edge, and operating height have an effect. Excessive dirt within the harvested stover can easily occur. This dirt only adds cost to the baling, and causes excessive wear on processing equipment.

7.1.4 Targeted Plant Parts--leaving the lower stalks

Leaving more of the lower stalk in the field can reduce moisture content of the stover harvested. This is especially true in the earliest side of the harvest season. The stalk dries from the top. A smaller amount of the lower stalk can be harvested by not using the baler attached flails.

Several crews operating square balers (McLaughlin and Jackson) and round balers (Hines and Shipper) in the GLCC project used this method -- raking unflailed fields. The results were qualitative, and warrant more study. An apparent drawback was that small clumps of stover pushed against the corn stalk stumps and resisted the rake, leaving small bunches of stover remaining in the field. Whether this created any problems for producers later was doubtful, but was not confirmed.

7.1.5 Reducing Moisture

Some day hybrids may produce stalks that dry down at the same rate as the grain. Until then, the flail and rake are the most effective tools for lowering moisture in a corn stover harvest. Flailing the field leaves the smaller stover pieces spread over the entire surface. This better exposes the interior of the stalk to the air and expedites drying. A day or two later V rakes effectively gather the dried, flailed stover into a large windrow, enabling high baling productivity.

7.2 Balers

7.2.1 Round

In the GLCC project John Deere Model 535 and 566 round balers with Model 561 Crop Shredders or Model 669 Crop Processors were mostly used. Balers that did not have the shredder or process attachment made less dense bails. The attachments are an after market accessory that mounts on the front of the JD baler and performs as a combination rake, shredder and flailer. Heartland Manufacturing, Inc., New Vienna, Iowa, manufactures them exclusively for John Deere. These attachments increase the bale density over non-chopped stover by 15% to 25%. The denser bale lowers surface wrap cost by $0.50 to $1.00/dry ton and reduces transportation cost significantly.

Power required increases from 80HP for the baler to 100HP with the Crop Shredder and 120 HP with the Crop Processor. The shredder operates at around 1,400 RPM and is not designed to operate in fields containing excessive foxtail or grass. The Crop Processor operates around 2,200 RPM and experienced fewer problems in grassy fields. The Crop Processor and the new version of the Crop Shredder (Model 565) have hydraulic height adjustment for varying the rake/shredder/flailing distance to minimize dirt pick up.

Most round balers used in the GLCC project had surface (mesh) wrapping capabilities. The advantages over twine are its better ability to shed rainwater in the field, less bale breakage after prolonged storage, and as much as 25% more production capability. The increased production results from less time required for putting on 3 wraps of mesh on the surface versus 20 plus wraps of twine.

Monitors in many of the balers allowed operators to observe how the bale was forming. Properly formed bales are easier to transport and stack than bell shaped or other irregular shaped bales.

Bale diameters between 32 to 72 inches could also be set with the monitors. When discharged from the baler, the bale often swelled up to 4 additional inches. This swelling is not as large with alfalfa hay.

The mega-tooth pickup is recommended. They last longer than the standard pickup teeth. Corn stover stumps are hard on pickup teeth and the bigger, stiffer mega-tooth lasts considerably longer.

High moisture kits for the balers also improve their operation for stover applications. These kits feature roll scrapers, mountings, and anti-wrap spirals to reduce roll wrap and crop build up; a major reason for low productivity when baling corn stover. Other options and after market products, such as carriers that allow extra or additional rolls of wrap can increase productivity. Consulting with the local dealers and custom baler operators is always a wise activity to benefit from their experience.

7.2.2 Square Balers

Large, rectangular and square balers were introduced in 1978 but relatively few exist in the Midwest compared to round balers. This is primarily due to the relatively small share of crops baled and their large capital cost--retailing near $70,000 compared to under $30,000 for a round baler. Square balers need large acreages to justify this cost. With increased interest in using Ag crops and residues for fiberboard and other uses such as biomass processing, large balers are expected to increase in number. Better service and easier access to a service technician can also be expected.

Several brands of large square balers were utilized in the projects. Hesston recommends a minimum of a 135 HP for the application. In the DES project, Case IH 8930 models were used with 180 HP. The Hesston 4900 4’ X 4’ baler manufactured by AGCO Corporation, Duluth, Georgia was the primary baler. A few Hesston 4750 3’ X 3’ balers and several Freeman 3’ X 4’ bales were used along with Hesston and New Holland demonstration models that produces 3’ X 4’ bales.

All of these balers are primarily designed and engineered for alfalfa, cereal straw, and grass hay production. Producing quality bales of corn stover or similar crop residues produces problems that exacerbate those that exist in hay and straw baling.

One of the most notorious problems is just keeping the knotters clean. Some operators stopped after every 40 bales to use a gas powered leaf blower to clean the knotters. Others mounted fans above the knotters that are supplied as an after market item by Harold Electric Co. (HECO), Walla Walla, WA. Hesston offers an air hose attachment to the knotters in an attempt to reduce the problem. None were completely satisfactory. Figure 9 shows the knotter cleaning and repair operation on the next page.

Figure 9.1, Knotters after partial cleaning

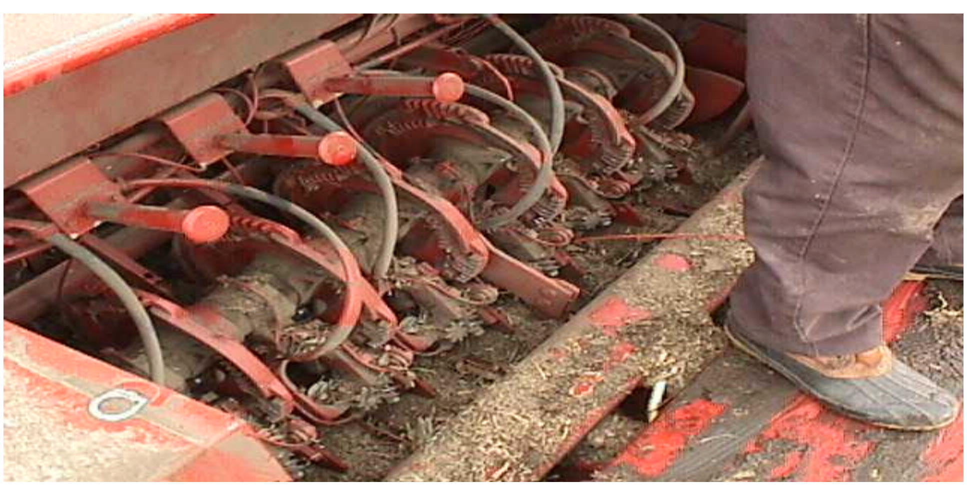
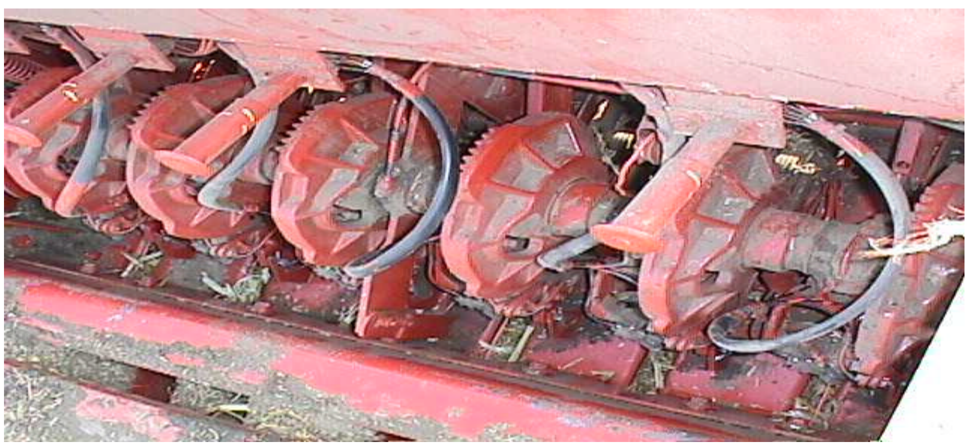


Figure 9.2, Repairing knotter

Figure 9.3, Cleaned and ready for operation



Dirt is a major cause of problems in baling regardless of bale size or shape. Minimizing dirt prevents many problems. Dirt collects in the lower outside corners of the bale chamber, changing bale shape. The best solution is keeping the pickup teeth above the dirt and creating a dirt-free windrow.

The 4' X 4' bales had inconsistent density. The top 1/3 of the bale is less dense than the lower 1/3. Balled corn stover varies more than baled. An attachment offered by the Maise Corp, Wichita, KS, Phone 888.722.8710 places more fine particles in the top 1/3 of the bale to partially offset this variation.

7.2.3 Importance of Size and Weight

Balers are capable of making most any size bale round or square. The larger and more dense the bale, the fewer handled for any specific tonnage. Normally, the least amount of bales to be handled would be synonymous with the least cost.

Even though big, heavy bales are normally more cost effective, local regulation concerning transportation can limit these parameters. Height, length, width, and weight restrictions need to be checked to insure compliance with transportation regulations.

Example: A trailer having a 54 inches deck height operating under state or local height restrictions of 13 feet 6 inches --as in Iowa--could have bales stacked up to 9 feet high on the deck. If hauling 4’ X 4’ X 8’ bales, one foot of potential payload space is not being used. If 3’ X 4’ X 8’ bales were used the full 9 feet of payload space could be used. In a state allowing heights of 14 feet 6 inches, 2 feet of payload space can be lost with the 4’X 4’ X 8’ bales. Knowing the deck height of the trailers intended is necessary as is local and state regulations in order to utilize the maximum available payload area.

With current balers, density of approximately 9 dry lbs/cu. ft. is practical when baling corn stover. Heavier densities can be achieved when baling alfalfa hay.

7.2.4 Effects of Dirt and Moisture

During stover harvest, dirt created baler problems in both projects, especially as moisture content increased. Increased baler wear caused by dirt should be expected in corn stover harvests versus most haying operations.

For round balers, dirt sticks to the belt and to the belt rollers. This build up can cause the mesh wrap to tear--resulting in a worse problem when the mesh sticks to the mud coated rollers rather than the bales. Cutting wrap off of rollers is dangerous and frustrating let alone time consuming. Balers equipped with high moisture kits or silage specials were less troublesome.

In the square balers, moist dirt builds up in the lower outer corners of the bale chamber and in time rounds the edges of the bales. Removing this buildup is time consuming. A panel with screen type perforations is available as an after market item from Maise Corp. The panel fits the under side of the charge chambers and filters out some of the dirt preventing the problem in the bale chamber. Plastic liners for the bale chamber may be another remedy, but never installed.

7.2.5 Importance, Consistency, and Density

A dense, consistently formed bale is important to both the transportation and storage operations. Round balers producing bell-shaped or oval-shaped bales should be stopped, pulled from production and remedied immediately. Irregular shaped bales are hard to load, contain on the load and difficult to stack properly.

They also pose a hazard to people in the stack yard and the public on the transportation route.

Round balers that utilize crop shredders and processors consistently produce higher quality bales. Large square bales with low-density results in uneven settling that can cause bale stacks to topple over. Monitoring each baler's performance through the harvest season is recommended.

7.2.6 Twine and Net Wraps

Quality plastic twine should be round and have 12 to 14 twists per foot of length. Buy newly manufactured twine, watch the use date, look for flat areas - kinks or knots, and store so rodents cannot gain access. Slight adjustments are often required when changing from one-knot strength or twine manufacturer to another if peak performance is to be maintained.

Only one supplier and knot strength was used for the DES controlled balers. In the DES project, Donaghys Inc., LTD of Vancouver, B.C., Canada offered a significantly better price and as high a quality as found anywhere. This twine was manufactured in New Zealand and was ordered in amounts that would totally fill large shipping containers in an effort to minimize costs. Thinking ahead allows time for delivery and can equate to enormous savings financially as well as time spent adjusting balers to accommodate last minute twine purchases where manufacturers might vary.

Most mesh wrap is produced by just a few manufacturers, but marketed through many retailers. Watch for rolls not completely round as they can be smashed by excessive weight during shipping or storage. Also compare length as different retailers order and market different (shorter) lengths to gain the perception of lower cost. Lower cost per roll is not necessarily lower cost mesh wrap. Buying wrap with a warning strip that signal operators when it is time for a new roll of wrap will reduce the instance of unwrapped bales released from the baler.

Sunlight and time break down the mesh wrap, and mesh with some UV resistance is desirable; recently manufactured mesh wrap offers the best potential results. When inserting new rolls of mesh wrap in balers some operators applied talcum powder to the rollers to reduce the chances of wrap sticking to feed rollers.

Surface wrap for round bales is the fastest wrapping option available. It cuts wrapping time to just a fraction of that of twine, savings of over 1 minute per bale is normal. When balers are producing 8 to 10 bales per hour, the increased productivity which mesh wrap offers goes a long way towards paying the additional cost of mesh versus twine. The mesh wrap also reduces tramp stover and offers much better rain water protection than twine wrapped bales.

The twine and mesh wrap were not separated from the stover. At GLCC the ground wrap and twine was processed with the stover. The plastic and twine were consumed in the process. At DES, plastic twine was not compatible with the horse bedding applications and removed before processing.

7.3 Bale Pickers

Bale pickers are available in a wide variety of configurations to meet the needs of different crops and volumes. Costs for industrial balers for relatively high levels of productivity and utilization such as Harlan approach $30,000. Smaller models designed for mostly farm use cost less than $10,000.

7.3.1 For Round Bales

Seventeen different bale pickers were considered by IHCF for use in the GLCC project. All were innovative and selection was based on the following criteria:

- Automated loading and off loading
- Accommodate mesh wrap
- Carry a minimum payload of 10 ton
- Strong enough for continuous use
- Conform to height and length laws of the Iowa D.O.T.

Most of these manufacturers offer videos and many are willing to provide demonstrations. The following is a list of the manufacturers whose equipment was originally considered.

Inland Steel and Forgings, Ltd.
675 Washington Ave.
Winnipeg, MB R2K 1M4
(204) 667-7854
Contact: Henry C. Neufeld

Horst Farm Wagons – sold by:
Westwood Distributors, Ltd.
Contact: Richard Cote
(204) 379-2220

Hay Master
CTS Distributing
Box 47
Ludell, Kansas 67744
(785) 626-9224

Wilson Mfg., Inc.
312 W. 5th
Cherokee, Oklahoma
(405) 596-3381

Richardton Manufacturing Co.
Box 290
Richardton, North Dakota 58652
(701) 974-3356

Blanchat Mfg.
P.O. Box 444
Harper, Kansas 67058
(316) 896-7145

Hecla Industries, LLP
P.O. Box 128
Hecla, South Dakota 57446
(888) 994-9797

MacDon, Inc.
9700 N.W. Conant Ave.
Kansas City, Missouri 64153-1832
(816) 891-7313

Buffalo / Kingsman
Fleischer Manufacturing, Inc.
P.O. Box 848
2281 16th Ave.
Columbus, Nebraska 68602
(402) 564-3244

Stinger Bale Transport
Stinger Ltd.
Haven, KS
(800) 530-5304

881 Series Hay Hiker
Morison Industries Ltd.
Available through distributors

Golden View Fabrication
Box 315
Smoky Lake, Alberta, Canada TOA 3CO
(403) 656-3575

Bale Bandits - (Haulers of straw bales through W. Canada)
Contact: Steve Wince
Alberta, Canada
(403) 843-6502 Evenings

Pronovost
260 Route 159
St. Tite, Quebec, Canada GOX 3HO
(418) 365-7551

Mumby Bale Wagon
Mumby Manufacturing, Ltd.
St. Brieux, Sask., Canada SOK 3VO
(306) 275-4510

Methods that squeezed bales or loading systems that had cleated chains were not suitable for mesh wrap and were excluded. Also excluded were those that did not conform to Iowa D.O.T. regulations, 40 ft length and 12 ft 6 in width.

However, as a result of recent changes in the D.O.T. regulations, some bale pickers that were originally rejected should be reconsidered. They are used extensively in the western U.S. and Canada.

7.3.2 For Square Bales

Six different square bale pickers were considered. The Bale Pro, Stinger, and Haying Mantis' approach the bale from the side. They all require crossing the corn rows or ridges that was not suitable for corn. A bump and turn method is also used that did not require crossing the rows. Bumping into one corner of the bale with the bale picker causes it to slide and turn 90 degrees and then meets the picker's loading arm without the unit crossing the rows. Although these pickers were able to work effectively for other applications, the bale may include more dirt in the sliding or turning process. It was also felt the number of broken bales would increase slightly.

The Stinger and Mantis are self-contained power units or truck tractors. Both pickers included movement of the bales in front of the truck and over the cab. Additional maintenance results from cleaning stover debris out of the radiator and the truck cab area.

The Freeman, American Eagle, and the Inland 4000 are designed to follow the same path as the baler. The Freeman and the Eagle operate with a self-contained power unit, while the Inland 4000 incorporates the use of a farm tractor. Each had their advantages and disadvantages and decisions as to which is best will incorporate the needs of the individual contractor. Iron Horse Custom Farming's decision on purchasing the Inland 4000 was influenced by:

- No need to bump and turn
- Lower cost when already existing power unit was available
- Power unit (Farm type JCB tractor) could be more usable for other farm work during the spring planting.
- Positioned bales on their side when stacked allowing a more stable or predictable stack with twine off the ground.
- Carried more bales, which allowed direct delivery to the plant

Some of these units stack the bales with twine on the bottom and top, others stacked the bales with the twine on the side. If using a baler that produced 3' X 4' X 8' bales perhaps stacking so that strings are at the bottom and top would be desirable. Although when stacking 4' X 4' X 8' bales or intermediate bales (basically 3' X 3' X 8') stacking so that twine is on the side might be preferred.

The main reason for this preference is that the top half of the bale is less dense than the bottom half. When stacked with strings to the top and bottom (as they are when they exit the baler) the bales settle and in time the bales lean one way or the other unpredictably. When stacked with twine on the side, the direction they might lean is more predictable. The less dense the top of the bale (as it exited the baler) will tend to be softer and the bales will lean in that direction.

Example: If bales are stacked with twine on the side, top of the bale to the left then the stack will normally lean to the left. With planning, tiers of bales within the stack can be aligned to lean toward each other and increase stack stability.

Vendors include:

Bale Skoop – Pro Ag Designs, Inc.
1700 Amsterdam Rd.
Belgrade, MT 59714
(406) 388-7799

Inland Steel and Forgings, LLC
675 Washington Ave.
Winnipeg, MB R2K 1M4
(204) 667-7854

Stinger Bale Transport
Stinger Ltd.
Haven, KS
(800) 530-5304

American Eagle
Circle C Equipment
Bend, OR
(541) 567-2992

Haying Mantis
Justice Enterprises, Inc.
P.O. Box 563
Sterling, CO 80751
(970) 521-9567

J A Freeman & Son INC
2034 NW 27th AV
Portland, OR 97210
503 222-1971

7.3.3 Auto Off Load

All of the automated bale pickers were able to automatically off load themselves. Methods involved tipping or dropping off, cleated chains on which the bales traveled, hoist or push off systems and in the case of square bales hoist and stack methods.

The cleated chain method rips the mesh wrap. Burrs on the rails on which the bales slide cause problems, but were easily remedied in the push off methods.

When delivering bales directly to the plant or collection point, the ability to automatically off load was a big advantage. These automated pickers did not have to wait in line to be off loaded by GLCC, but could simply pull near where stacking was taking place, off load and be on their way.

7.3.4 Squeezes and Spears

Squeezing bales is the preferred method for placing bales on the carrier decks by most of the automated square bale pickers manufacturers. Those pickers that applied the pressure of the squeeze to the side of the bale versus a twine side were preferred. Pressure on twine can increase twine breaks. Missing twine increases the amount of future breakage.

Some automated square bale picker manufacturers used spears or claws, which probe into the bale. This method also causes twine breaks and alters the bale shape as these claws often remove some corn stover when they are retracted from the bale.

Manufacturers of round bale pickers prefer a system of loading bales onto the carrier decks with lift arms hinged to the carrier deck. These lift arms entered under the wide area of the round bale and then lifting upward while cradling the wider area of the bale until bale rolls onto carrier deck. Differing lift arm configurations exist among manufacturers and all are effective even though some maybe better than others.

7.3.5 Compacting Concerns

It seemed that the larger the load the more producers were concerned with compaction. Heavy wheel loads are believed to be the cause of most deep soil compaction. The volume of soil compacted by a wheel pass varies with soil type, soil moisture, tire size, pressure, and total load size. Therefore, concerns can be reduced if tire area in contact with the soil is increased in the same proportion that the load weight is increased.

Suggestions:

- Consider soil type and compaction issues and discuss at time of stover procurement.
- The pounds of pressure per square inch of tire in contact with the soil should be similar or less than the producer’s combine and grain wagons. Add more axles and tires or increase tire size if wheel pressure exceeds most area producers.
- Complete bale removal from fields before spring thaw.
- Stay out of wet fields or at least receive permission from producer if fields are in question and work needs to be completed.

7.4 Transports

7.4.1 Automatic Containment

Automated bale picking and off loading trailers were used in the GLCC project. The sketch below shows the side rail on the trailers up along the side of the bales, approximately 24 inches higher than the lower portion of the bales. The top row of bales was similarly contained by the opposing curves of the two bales below. A hydraulically controlled tail gate came up 18 inches on the back of the load and kept bales from sliding off of the back of the trailer.

A safety indicator light inside the power unit cab shows if the tailgate is not in its full upright position. This bale containment system was time efficient and reliable. Automated trailers hauled approximately 90% of the bales while conventional semi trailers hauled the other 10%, utilizing four-inch wide nylon straps for containment. Mishaps occurred with both methods.

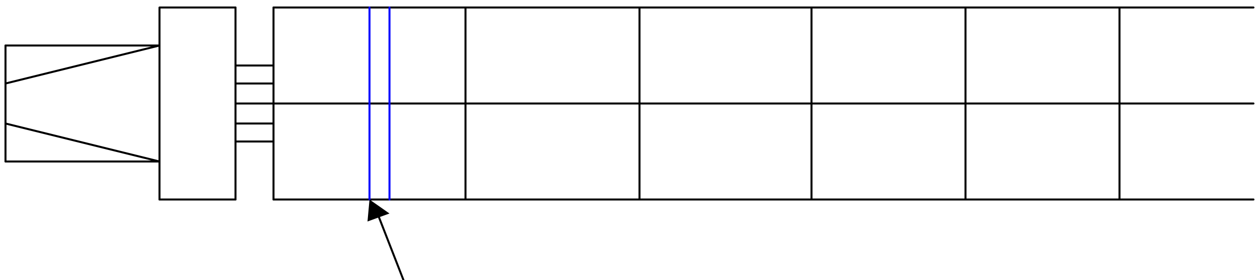
- Two incidents occurred with the automated containment systems when the tailgate was not in the full upright position due to a failed cable connection or broken cable and the failure of the driver to respond or notice the warning light.

- Ten incidents occurred with the conventional containment systems using straps. The most frequent cause was loose straps resulting from bales settling as they jogged along the road.

The savings in time offered by the automated containment should be realized as a major advantage and should be improved upon and became the primary method. Laws and legal definitions for containment may need to be reexamined.

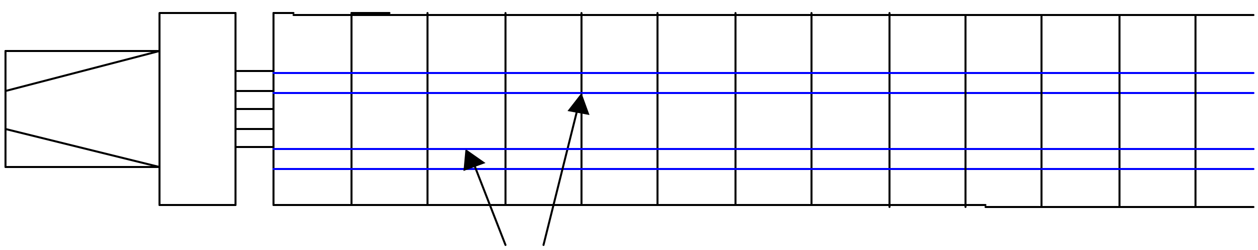
7.4.2 Methods of Strapping or Tie Down

Two different methods of strapping or securing bales prior to movement were used. The most common method for strapping from side to side is below.



4 inch Wide Nylon Straps over the center of each group of four bales

The second is less commonly used, but is believed less time consuming to apply although no actual comparison was made.



Two 4-inch Nylon Straps lengthwise over the entire trailer

4 inches wide straps are preferred over the 2 ½ inches straps.

7.4.3 Regulation

In Iowa, drivers hauling more than 26,000 pounds must have a CDL (Commercial Driver’s License). Special endorsements or restrictions apply to a CDL in addition for double/triple trailers, or units that are equipped with air brakes.

If the transport unit hauls for hire, which most stover haulers using semi trailer combinations will, they need travel authority. Owners of trucks and semi trailers

Gross Weight: 80,000 pounds

Weight must be properly distributed over the axles. Maximum load = single axle 20,000 pounds. Tandem axle = 34,000 pounds. Special annual permits from the state are available and cost $25 for loads exceeding 8 ft 6 in up to 12 ft 5 in, length up to 75 ft, and height up to 14 ft. Some county and city permits must be obtained separately. Crossing into another state may require fuel permits and quarterly reports. Wide loads may not be allowed on certain days of the week.

Safety regulations include maximum drive time of 10 hours on and 8 hours off (a maximum of 60 hours per week), on duty time limits, along with annual unit inspections. Drivers must be 21 years old, carry a doctor's certification that they are physically qualified to drive. Most states have similar complicated regulations covering truck, semi trailers, and their drivers. Those operating implements of husbandry (farm type tractors pulling trailers, which include JCB's and Unimogs) are exempt from most of these regulations and not subject to their fee.

7.4.4 Field Entrances

Currently many field entrances are not wide enough, too steep, or for some other reason do not allow easy and safe entrance to the field. This is especially true for the longer transportation equipment necessary in a stover harvest. It is reasonable to believe that producers will improve these entrances with very little expense incurred if motivated by the economic incentive of the stover harvest.

7.4.5 Flatbed (Drops and Double Drops)

Drop deck trailers can increase the payload area, but can also create problems entering and exiting the fields due to their lower ground clearance. Double drops are excellent units for maximizing payload, but can offer as little as 10 inches of ground clearance.

7.4.6 Producers

In the Midwest, producers' equipment for moving round bales are designed for on farm use and do not include options that improve road safety, such as extended mirrors, lights, and proper containment. Most are designed to haul 4 to 8 large round bales. Although there are more road worthy units available with larger load capacity most producers have no need for them. In the case of large square bales, most producers do not possess efficient handling and loading systems, but flat deck semi trailers and trucks are not unusual.

7.4.7 Semi Tractor Off Road

The harvest season for corn stover in the northern corn belt means short days in terms of sunlight. Damp, muddy field conditions normally exist. Operations of semi tractors in the field are hampered by these conditions. The equipment should be equipped with additional or wider tires that apply less pounds of weight per square inch of soil surface to avoid soil compaction. Bales should be staged near the road to keep field travel minimal. The operator should be prepared to occasionally assist other units back on to the road with a farm tractor and tow chain, better enabling them to be a viable option.

7.4.8 Conventional Farm Type Tractor

Tractors provide the chief source of power on most farms. They are differentiated from over the road semi tractors by their ability to provide power for other farm machines. These features include the drawbar, a hydraulic system, and a power take-off. In the U.S., farm type tractors normally are designed for moving between 17 to 24 miles per hour. They typically travel on large lugged tire. The legal definition of a farm tractor does not limit its' speed. However, state Implements of Husbandry laws may restrict its' speed on the road.

Faster traveling farm type tractors are emerging that can operate safely at speeds up to 50 miles per hour. Implements of Husbandry were recently revised and now allow 35 mph, 5 mph faster speed in Iowa than was previously allowed.

7.4.9 Farm Type Tractors With High Road Speed Capabilities

In the GLCC project it was decided that considerable savings in transport of corn stover was potentially available by using the much faster European style tractors; the JCB Fastrac 185 manufactured in the U.K. and the Unimogs manufactured by Mercedes-Benz in Germany.

The JCB's offered air over hydraulic brakes that give excellent braking ability, similar to that of an over the road truck. A combination hydraulic over air and coil spring suspension provided a smooth ride even when crossing rows in the field.

These features reduce driver fatigue and provide a safer working environment. Better control, shorter turning radius and additional traction of the gooseneck trailer were especially helpful when entering narrow field entrances. The JCB was able to safely travel at speeds over 40 miles per hour.

The Unimog is capable over 50 miles per hour road speed. The Unimog sat lower and had less visibility. Unimogs are more expensive than similar powered JCB units. Both are able to increase productivity of harvest crews and reduce cost of transportation and handling over conventional tractors. They also offer improved traction in the cornfield compared to over the road trucks.

7.4.10 Safety, Breaking, and Traffic Flow

When moving transport units from the field onto the road, often the transport's wheels will deposit a certain amount of mud. This mud can become a safety issue and scraping off or some amount of clean up may be necessary.

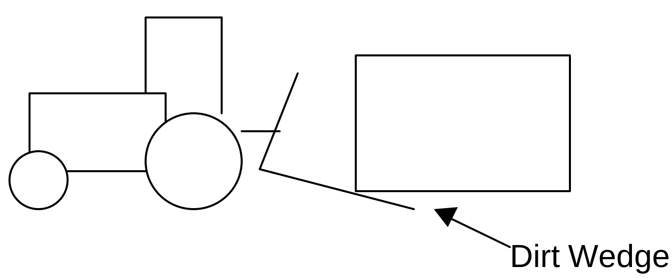
The power unit pulling the load should be heavy enough to stop the load when the brakes are applied or brakes should also be added to the trailer wheels. Currently, many of the farm trailers, which some producers might use, are not equipped with trailer brakes and their safety should be examined.

Tractors capable of higher speeds used in the GLCC project were equipped with air over hydraulic brakes along with electric trailer brakes (note: air brakes on trailers might be an improvement). These JCB-Inland units were also equipped with trailer lights, extended mirrors, mud flaps and reflectors. Traveling nearer the speed of normal traffic reduces the overall time spent on the road in traffic. Faster traveling tractors also reduces the amount and frequency of traffic backing up behind these transports versus slower moving farm tractors.

7.5 Stacking and Staging Equipment

7.5.1 Forks and Platinums

Picking bales up in the field and loading them onto trucks with a forklift equipped with forks or platinums is not recommended. Large chunks of dirt are pressed into the bottom of most bales. Investigation showed the dirt was caused by the angle of the platinum when it picked up the bales in the field for loading onto trucks.



7.5.2 Squeeze Arms and Spears

For loading and stacking with a squeeze attachment, one arm movement is best. . . preferably to the driver's right side of the squeeze when moving from the closed to the open position. A squeeze attachment on the telescopic handlers was preferred over spears or forks when handling square bales in the DES project. Squeeze systems tended to rupture the mesh wrap on the round mesh wrapped bales.

The squeeze attachment was under-designed for this application. Broken welds occurred after handling a few hundred bales. The manufacturer offered to repair them under their warranty if returned to the factory, allowing several weeks for the repair to take place. This was unacceptable, as harvest was already underway when the problem was discovered. The squeeze attachment was strengthened in this area by DES personnel at DES's expense. The manufacturer voided any further warranty. This version lasted considerably longer, but welds and metal fatigue still required too frequent repair. It was decided that a revised hydraulic pressure regulator with pressure relief valve is most likely required to correct the problem. This would hopefully reduce frequency of repair.

Spears were preferred in the GLCC project since most bales were large round and mesh wrapped. Many different types of spears exist. A forged tapered spear was preferred over the pointed shaft type. This tapered spear saved labor and improved the integrity of the stacks. Resistance to the non-tapered, pointed shaft was a problem especially in the higher density bales. This resistance occasionally made it difficult for the spear to enter and exit the bales. The wiggling that it took to remove the spear often caused the bale's placement to become somewhat precarious within the stack. The forged tapered spear assured insertion and removal of the spear with little resistance. The forged steel spear resisted bending unlike the shaft type spears.

7.5.3 Telebooms

Known by many names: telescopic handlers, telebooms, and load-alls, they combine the attributes of forklifts and wheel loaders. The units are highly functional for loading bales on trailers at the field site or stacking them at the yard. The smaller lift capacity units normally offer the best maneuverability. The heavier units provide more stability and safety when equipment is mostly extended to place a bale toward the top of the stack.

When choosing the best unit for the job, stack height and cab visibility are major considerations. Lift capacity is dependent on extended height. With an experienced operator in the proper unit, two to four large bales can be handled per minute. If near the ground the time is a bit less, if over 40 feet high the time will be greater. As described in 7.5.2, DES used squeeze attachments and GLCC used spears. Units are available through most agricultural implement or construction equipment dealers.

7.5.4 Road Runners

A Road Runner is a type of forklift that can work in field conditions and moves down the road at high speeds. It can utilize a squeeze system rather than forks exclusively. They improve loading operations from one field to another. Road Runners, as they are called in the northwest part of the country, are common in the straw and hay harvest. They are also used at the plant sites for off loading, etc. at companies like Anderson Hay of Ellensburg, Washington; Aurora, Oregon; and Brawley, California.

These units are themselves heavy and are capable of moving several bales at once. These units were not used in either the DES or GLCC projects, but deserve consideration in the future. Some testing to better evaluate their operability in the cornfields of the Midwest is suggested. Wetter, softer fields might cause excess compaction or could cause problematic operations. A few different companies manufacture versions of the Road Runner. However, one of the primary manufacturer is the Road Runner Company of Manteca, California (209-823-5261).

7.6 Fueling and Service Equipment

7.6.1 Safety and Regulations

In the DES project diesel fuel was transported to the field operations using tow tanks with approximately 500 gallons capacity each. Some had a series of baffles within the tank that kept fuel in a partially filled tank from rushing forward inside the tank when stopping at an intersection. These tanks without baffles caused the pickup truck pulling the tank to jerk back and forth with the fuel movement inside the tank. The fuel movement was minimal when the tank was completely full or empty. Baffled tanks were considered safer and could be pulled at faster speeds.

Regulations restricted movement of fuel in these tow tanks to diesel and did not allow gasoline to be moved in this manner.

Maintaining a supply of fuel is key, since operations continue around the clock, on Holidays and weekends. Bulk delivery trucks are extremely busy during the harvest season. Often they cannot be scheduled for a specific time or location. Even if the harvest company has their own fuel delivery truck it is difficult to coordinate deliveries. Harvest equipment is continually moving from one field to the next. Exact delivery times are not possible to predict.

7.6.2 Diesel Versus Gasoline

Power units that utilize diesel are preferred, especially on hauling units and those working in the bale yard. Even though exhaust from diesel engines can produce sparks; it is far less frequent than a gas engine. The use of exhaust system spark resistors or inhibitors further reduces the risk of sparks from the exhaust.

Transportation regulations of fuel to field operation vary from state to state and are constantly changing. Potential liability could be devastating to any company if the laws are not followed. Complete understanding and compliance is a must.

Fire codes also regulate the amount gasoline storage allowable and regulations are more stringent than with diesel.

7.6.3 Contracting

At the onset of the DES project, fuel prices were at or below a twenty-year historical low. Management felt protecting the cost of harvest by locking a firm fuel price for the entire season was in order. Three options were considered.

- Hedging fuel position – using home heating oil required approximately $2,500 up front
- Contracting with Downing Fuel Delivery Service Company
- Contracting with the fuel terminal for direct delivery had to accept delivery in semi transport load amounts

Contracting with Downing was the final choice. A four-cent per gallon premium was paid to Downing. For the service, DES received free usage of six tow tanks, a total maximum capacity of 3,000 gallons not considering tractor and equipment tank capacities. A twenty-four hour notice was required by Downing, all tanks were to be filled at one location near the DES plant.

This saved renting or purchasing tow tanks for the field operations as well as eliminated advance payments, margin calls, or up front money. Downing presented a bill after filling tanks and allowed thirty days for payment. The price on 42,000 gallons was set during the summer prior to harvest at sixty-four cents/gallon for off road diesel.

CHAPTER 8. SUMMARY AND CONCLUSIONS

8.1 Communication

Establishing a successful corn stover harvest operation requires wide communication and much advance planning. All growers are potential suppliers.

Properly identifying those to closely communicate and work with helps lay the foundation for recruitment of producers to supply adequate material for harvest.

Open communication is the best tool for overcoming concerns and the opposition, using the media, public meetings and individual meetings with key people to reach as many people as possible. The benefits from removing excess stover are substantial. Providing facts related to sustainable harvest in many forms--in simple terms to communicate to the average person, and in economic and technical terms for those requesting a more comprehensive understanding helps recalibrate traditional value judgments. While public meetings are necessary, one-on-one meetings to address the individual's concerns are the most important. Gaining an understanding of the reasons for the other perspectives is essential for effective discussion.

8.2 Planning

Planning every detail of the harvest insures proper preparation. No one likes to be surprised. Since this is the first harvest, more time and attention is required. Allowing for adequate time in advance of the harvest to meet with the producers at their site, map locations, document directions and instructions results in an organized harvest and better insures happy customers with no complaints.

8.3 Selection of Custom Operators

Selection of skilled contract harvesters with the right equipment for the first stover harvest builds another platform for success. Additional time is needed the initial year to match them up with producers, adapt their methods and equipment to a different harvest and follow their performance, managing by exception and rapidly correcting any problem.

8.4 Coordination of Harvest

Coordinating the harvest operation with the producer and custom operators is key to keep baling equipment fully utilized and the producer satisfied. Prompt clean up of broken bales is required. Anticipating problems and prompt response to new conditions and incidents all require coordinating activities at a high level of performance.

8.5 Harvest Equipment.

For the actual harvest, the most proven, lowest cost collection method for corn stover processed to chemicals, fuels and other fermentation products is baling the windrow with a round baler that has a height adjustable flailing attachment. Adding a wheel rake in front of the tractor can increase the harvest if desired. Surface wrapping the bales with three layers of a UV resistant plastic mesh minimizes breaks as the bales are collected, transported, unloaded, staked and retrieved for processing.

Large square balers may be adapted to equal the round baler cost performance with more experience, especially when harvesting large, relatively regular shaped fields as in Central Illinois. The cost of the separate flailing and raking operation may be offset by greater baling productivity.

Load and go wagons pulled by high speed tractors that permit one operator to load the bales in the field, safely travel to the storage site at normal road speeds and self-unload offer the lowest cost within a 50 mile collection radius. For greater distances, square bales on flatbed trailers usually offer an advantage.

Outside storage of surface-wrapped round bales is less likely to offer stack problems than storing square bales under tarpaulins or other type of wrap. The inherent variation in square bale density may result in the stack shifting, tearing the wrap with resultant bale spoilage. In any event, both should be stored on a raised, easily drained surface to avoid excessive loss of the bottom bales.

Purchasing the bales on a dry basis offers more control than an "as is" basis. Incoming shipments are best weighed, sampled, analyzed for moisture and possibly coded for inventory control.

8.6 Outlook

Future Extensions include less need for "harvest coordinators" and custom harvestors, use of a more diversified feedstock, activities that reduce transportation cost -- including revising laws and regulations, further collection improvements, inventory shrinkage prevention methods and co-product collection.

In following years, the contract harvester and producer generally work directly without the need for additional coordination. As experience is gained, it is expected more producers will favorably consider including harvest, collection and transportation roles within their farmgate operation. The degree this occurs is likely to depend on confidence of an ongoing market for the harvested material and the margins they can expect.

Diversified feedstock for a biomass processing plant is available in addition to corn stover. Much of the same collection equipment is utilized. Creating the infrastructure for corn stover processing reduces economic barriers for collection of other residues and dedicated energy crops. Timing of harvest varies, and improved equipment utilization results. The result is a decline in fixed costs, lowering collection costs without shrinking margins. Soybean stubble is collected now for animal feed, yielding between 2.2 to 3.5 MKg/ha (1.0 to 1.5 tons/acre) dry weight. Switchgrass becomes attractive with lower collection costs. Alfalfa and other grasses are possibilities, especially if the planned protein extraction plants for alfalfa proceed. The certainty of a diversified crop base reduces the custom operators and processor's dependency on a few crops, enhancing the economic possibility for capital investment. Other feedstocks increase the comfort of the potential processor, reducing the risk of a one-crop disruption.

Transportation cost reduction is occurring now with wider use of JCB/Unimogs type tractors that shorten travel time between field and collection centers. More collection centers with a smaller collection radius will emerge. The increased number coupled with central scheduling of collection equipment will allow high utilization of these resources, adjusting to changing field and weather collections, insuring timely and efficient harvest.

Legislation and regulatory changes to better standardize requirements and facilitate safe, efficient and easy state to state and Canada and US highway equipment operation can also reduce cost. Iowa has already made changes that permit custom operators to operate under the same conditions as the producer when transporting crops from field to markets. Without this change, additional license and insurance fees would have increased cost for the operator.

Further cost improvements in the baling, wrapping and collection equipment and process is expected to increase payload and lower cost by 20% or more. A variety of equipment development plans are underway, such as adapting cotton harvest compaction trailers, making improvements to balers to operate at greater compaction pressure and re-designing the dated 'stacker' for high volume, custom operation. Ag machinery equipment suppliers can anticipate a large market for corn stover collection. While there are many underutilized balers, the opportunity for expanding sales is expected to drive innovations that will better serve this market.

Inventory shrinkage prevention continues to be investigated. Processing high moisture round bales and uncovered square bales during colder weather can minimize inventory shrinkage. Wrapped round bales with moisture levels less than 20% remain stable, and may be processed later in the season at a rate to match processing requirements. Bunker storage similar to silage is another option that can reduce cost when transportation distances are short for the lower density product.

Co-product collection via bales offers considerable flexibility and provides an attractive alternative to collection systems in place for corn, soybeans, wheat and other cash crops. The co-products may be milli- or micro- quantity components present in the plant or an expressed material in a transgenic plant.

Cash crop systems are designed to move large volumes of homogenous material efficiently. They are not readily adapted to segregating materials or handling "special" situations. Cross-contamination would be an ever-present concern. If contamination does occur, the mistake is usually irreversible, as mechanical separation of physically identical grain is not possible.

Baling allows easy segregation. Bar-coding bales provides low cost, accurate inventory control. Co-products can be separated at the collection center. The processed biomass may be re-baled using an industrial baler and later transported. The valuable co-product can be collected for further processing on site or elsewhere.

In summary, the Harlan Project offers the opportunity to speed the development of BioEnergy production in the corn-growing Midwest region. It serves as a model to further the infrastructure development for biomass collection to supply a sustainable energy future. Present possibilities are expected to reduce the baling cost 20%, to less than $30 per dry ton without reducing the growers and custom operators margins.

Appendix A
Stover Hauling Considerations & Profitability
1998 GLCC Program

This Appendix provides an explanation and example calculations of the economics for hauling corn stover.

Short-haul trucking companies generally feel that over $350 per day, five days a week, 260 days a year of revenue is needed just to stay in business. This is not a perfect rule as it depends on variable costs, which are affected by fuel usage, tire wear and differing risks of breakdown or other mishaps, such as getting stuck. Always operating on hard surface roads minimizes breakdowns and mishaps, but this type of haul normally is very competitive. When hauling stover from farmers' fields mud and narrow field entrances increases the risk of mishaps.

For all types of hauling, strategies to increase profits need to be considered. For example, running more hours can increase profits, since fixed costs remain fairly constant whether the truck runs 4 hours or 24 hours per day. Using longer trailers to carry more tonnage is another possibility: 53' trailers or 30' flatbed trucks with a 28' pup has the longest load carrying area (58') and the most flexibility when turning into field entrances. The 3'X4' bales can be stacked 3 high on a 54" high flat trailer and still are

Dollars per loaded mile is another common method of determining whether the load will be profitable. In the Midwest $2.00 per loaded mile is acceptable for a normal haul--$1.85 for longer distances and $2.40 for shorter hauls. If back hauls are available, lower prices can be profitable.

Table A-1 includes estimated dollars generated per hour. The truck sitting still while being loaded or off loaded still needs to generate revenue to cover fixed costs. One strategy to help reduce the dollars needed while the truck is sitting is to have the driver operate the equipment that transfers the corn stover. An example calculation results in

$1.70 per ton X 16.8 ton on a load = $28.56 in forty minutes or $42.84 per hour savings. The cost of the loading equipment is $13.00 per operating hour, if enough hours were put on per month. As an example, a rental charge of $2,000 per month for up to 160 operating hours. If it is used to load 6 loads per day, 6 days a week, for 4 weeks at one-half hour on tachometer per load it would equal 72 hours on the tachometer at a cost of $27.77 per hour. If it was used for the full 160 hours, it would cost $12.50 per tachometer hour (some repair costs may also be necessary, such as tires). This again demonstrates the advantages of shift hauling to the efficiency of the total operation.

- Pay Per Dry Ton: These numbers include staging at $3.25 and loading at $1.70 per dry ton.

- Semi Hauling: The $3.25 per ton for staging and $1.70 per ton for reloading have been subtracted, so that hauling and the different ways of looking at it could be more accurately reflected. A 16.8 ton per load was used as an average.

- Estimated Loads Per Hour: This column is based on figures from 1997 deliveries of intermediate square bales (3'X3') with travel speeds averaging 50 mph. The 1998 loads per hour have the potential of being significantly increased.

- Range of $ Per Hour And $ Per Loaded Mile: Are calculated using the high mile and low mile in that bracket of loaded mile.

- Average $ Per Loaded Mile: Are calculated by using the average miles in the bracket.

- Estimated $ Per 10 Hour Day: Are calculated by using estimated loads per hour times semi-hauling load of 16.8 tons of dry matter times 10 hours.

Table A-1
1998 HAULING CALCULATIONS – SEMI TRACTOR TRAILERS

Loaded Miles	*Pay/ Dry Ton*	*Semi Hauling 16.8 Ton*	*Est. Loads Per Hour*	*Range of $ Per Hour*	*Range of $'s Per Loaded Mile*	*Avg$/ Loaded Mile*	*Est. $'s Per 10 hr. Day*
1 – 5	$5.60	$10.92	.73 - .65	$7.97-$7.10	$10.25-$2.18	$6.55	$75.35
6 – 10	$6.60	$27.72	.64 - .58	$17.78-$16.11	$4.63-$2.78	$3.70	$169.45
11 – 15	$7.85	$48.72	.56 - .52	$27.78-$25.33	$4.43-$3.25	$3.84	$219.45
16 – 20	$9.60	$78.12	.50 - .47	$39.06-$36.72	$4.88-$3.90	$4.39	$378.50
21 – 30	$12.10	$120.12	.46 - .39	$55.26-$46.85	$5.72-$400	$4.86	$510.50
31 – 40	$13.10	$136.92	.39 - .34	$53.40-$46.55	$4.42-$3.42	$3.92	$499.75
41 – 50	$14.10	$153.72	.34 - .30	$52.26-$46.12	$3.75-$3.07	$3.41	$491.90
51 – 60	$15.10	$170.52	.30 - .27	$51.16-$46.04	$3.34-$2.84	$3.09	$486.00
61 – 70	$15.60	$178.92	.27 - .24	$48.32-$42.95	$2.93-$2.56	$2.74	$456.35
71 – 90	$16.10	$187.32	.24 - .20	$44.96-$37.46	$2.64-$2.08	$2.36	$412.10
91 – 125	$17.10	$204.12	.20 - .16	$40.82-$32.66	$2.24-$1.63	$1.94	$367.40

Since the 125 mile radius haulers may travel is broken into 11 brackets; there will be a difference of pay-per-mile within each bracket. This also affects loads per hour. A 40 minute load time and 40 minute off load time (total load and off load time = 80 minutes) for intermediate bales was used in the calculations. An average road speed of 50 mph was used. Load and off load times will be greatly improved with 4'X4' bales verses the 3'X3' bales, perhaps as much as 30%, which means considerably more loads per day.

As the tables indicate, hauling with semis is not economical within the first 20 miles. For example, in close a JCB (i.e., a fast traveling farm-type tractor) pulling a unit capable of picking up the bales as they were randomly placed in the field by the baler would receive the $3.25 per dry ton otherwise reserved for the stager.

When the bales are hauled in directly to the plant, there is no reloading charge. A self-picker can receive the entire pay per dry ton. However, to avoid excess compacting, these units are only able to haul about 60% of the normal payload of a semi or truck and pup. Most often they will need more traction than an over-the-road truck offers. This type of unit needs to generate $50 to $60 per hour to enable a reasonable profit for drivers and equipment owners and can be economical up to 40 miles. The chart below gives an idea of how this might pay based on the 1997 corn stover harvest. Strategies for increasing profits with JCB and self-pickers would include equipment being mounted on the front of the JCB with the ability to carry an additional bale or breakage and to operate 24 hours a day.

Table A-2
1998 HAULING CALCULATIONS – JCB TRACTORS W/SELF PICKER

Loaded Miles	*Pay Per Dry Ton*	*JCB Hauling 10.2 Ton Total Revenue*	*Estimated Loads Per Hour*	*Estimated $ Per Hour*	*Estimated $ Per 10 hr. Day*
1 – 5	$5.60	$57.12	1.7	$97.10	$971.04
6 – 10	$6.60	$67.32	1.07	$72.03	$720.32
11 – 15	$7.85	$80.07	0.79	$63.26	$632.55
16 – 20	$9.60	$97.92	0.62	$60.71	$607.10
21 – 30	$12.10	$123.42	0.48	$59.24	$592.42
31 – 40	$13.10	$133.62	0.36	$48.10	$481.03
41 – 50	$14.10	$143.82	0.295	$42.43	$424.27
51 – 60	$15.10	$154.02	0.245	$37.73	$377.35
61 – 70	$15.60	$159.12	0.21	$33.42	$334.15
71 – 90	$16.10	$164.22	0.175	$28.74	$287.39
91 – 125	$17.10	$174.42	0.13	$22.67	$226.75

APPENDIX B 1
Sample Worksheet for the Potential Stover Harvester

Value of Average Corn Crop

Average Yields for Shelby County over the past five years:

Year	**Avg. Bu/A**
1992	144.8
1993	85.0
1994	148.4
1995	113.8
1996	135.1
5 yr. avg.	125.4

Since we are considering high quality land vs. average we added 15% to the average.

Yield 144.2 BU/ACRE

Selling Price based on Iowa Farm Business Association Data collected as of March 21, 1997 for Southwest Iowa.

Year	Avg. Sell Price $/BU
1992	$2.11
1993	$2.02
1994	$2.22
1995	$2.38
1996	$3.30
5 yr. avg.	$2.41

Value of Corn Crop: (144.2 BU/ACRE) ($2.41/BU) = $347.52

Cost of a Corn Crop

Cost Item	Published Number **$/Acre**	Estimate Your **Farm $/Acre**
Land Value	$126.00	______________
Equipment, Fuel, Labor	$ 74.25	________________
Seed, Chemicals, Etc.	$123.08	________________
Total	$323.33	________________

Note: This figure does not include cost for drying, storage or shipping.

Land Value: Whether you own land or not it is a cost. It could be rented for the above amount. We used the rental rates for high quality land. The range was from $110 to $145 / Acre as shown in ISU 1996 Cropland Survey for Shelby County (Extension Publication FM1851).

Equipment, Fuel and Labor: Custom farm rates were used as shown in 1997 Iowa Farm Custom Rate Survey (Extension Publication FM1698). Rates varied from $51 to $100 depending on field shape, size and topography.

Seed, Chemicals, Etc.: The cost for corn following soybeans was used. It was felt that producers following with soybeans would more likely benefit from stover removal. The figure is based on 1997 issue of ISU Estimated Cost of Crop Production and Iow Farm Business Association Record Summaries (Extension Publication FM1712).

Seed 26,000K	$25.48	__________
Nitrogen at $.22 X 177#	$25.74	__________
Phosphate at $.31 X 51#	$15.81	__________
Potash at $.13 X 41#	$ 5.33	__________
Lime (year cost)	$ 6.00	__________
Herbicide	$25.75	__________
Crop Insurance	$ 4.20	__________
Interest on Pre-harvest Variable Cost	$ 7.77	__________
Miscellaneous	$ 7.00	__________
Total	$123.08	__________

PROFIT FROM CORN CROP

Value	$347.52 / Acre	Yes, there still is government subsidies, but it is shrinking each year and will be gone in 5 years. For the purpose of this evaluation We did not include any.
Costs	$323.33 / Acre	
Net Profit	$ 24.19 / Acre	

Profit per acre from Corn for the High Quality Land: $24.19 / ACRE
Your #: ________.

Now Lets Look At Value Added Corn Stover Harvesting

- For each pound of corn produced there is over a pound of corn stover (approximately 56% of total). Ref: Modern Corn Production by Aldrich, Scott and Hoeft.

  The yield used before of 144.2 BU/A would result in 144.2 BU/A (56#/BU) = 8,075 pounds of corn. There would be 8,560 pounds of stover produced. Even if you attempted to strip the field entirely you could obtain only 75% of or about 6,400 pounds.

- The GLCC Plan is to deactivate the chopper and/or spreader on the combine, thus producing a windrow of cobs, shucks, leaves and stalks. The baler will then bale this up along with the two rows of stalks in the windrow. We can expect about 3,000 lb/A depending upon: Corn yield, plant population, hybrid, combine head size, how long after corn harvest, and row width.

- For the example we will use 3,000# or 1.5 tons per acre. This leaves over 60% for soil conservation, fertilizer, humus, etc.

- Before the combine arrived we removed all the cobs along with the corn. After shelling, these were burned, used as bedding, or sold to the Furfural Plant in Omaha. The cobs make up as much as 20% of the total corn stover. In addition, corn yields have increased over 1 BU/A per year which means stover has also increased. Even after harvesting corn stover, today's producers have more stover remaining then most producers did just a few decades ago.

Nutrients

- Many studies and papers have been done on what nutrients are being removed by harvesting corn stover. Variation will exist on individual fields for all sorts of reasons. In 1997 two composite samples from over 50,000 bales of corn stover collected from hundreds of fields all over western Iowa. The samples were split and sent to two Laboratories (Woodson-Tenent Laboratories Inc. of Des Moines, Iowa and A & L Heartland Laboratories of Atlantic, Iowa). There were some expected variations among the four analyses. However, the average of the four is what we will use in the example. We are fairly comfortable with the average by analysis as it is also backed up by analyses of corn stover "ash" - a by-product of Great Lakes Chemical Corporation furfural extraction.

Corn to Soybeans (1.5 Ton stover removed)	$ / Acre
Nitrogen (not required if going to soybeans)	$0.00
Phosphate (7 lbs* 1.5) ($0.29/lb.)	$3.05
Potash (35 lbs * 1.5) ($.014/lb.)	$7.35
	$10.40

Corn to Corn	
Add Nitrogen (20 lbs.) ($0.16/lb.)	$4.80

- It is important to note that many things can reduce the need to add these nutrients; but for this analysis, none of these were included.
  - If you spread manure, you probably need very little of N, P, or K.
  - If a field's soil tests in the high or very high range, the P and K will not have to be replaced. (ISU, Dr. Voss)

OTHER SAVINGS

- Total or partial stover harvest most often will enable fewer tillage passes and make no till or minimum till more attractive. Normal tillage equipment is listed below along with average per acre rates for 1997 according to ISU's Iowa Farm Custom Rate Survey.

			GLCC	Your estimate
Shredding corn stalks		**$6.50**	________	________
Disking	--tandem	$7.15	________	________
	--offset	$9.00	________	________
Harrowing		$3.75	________	________
Soil finishing		$8.05	________	________
Field cultivating		$7.10	___$7.10____	________
Add to no till planter cost				
Over planter w/attchmnts		$1.79	________	________
Over planter w/o attchmnts		2.75	________	________

- Removal of corn stover lessens the carryover of insects and disease that live in the decaying residue.

- Large quantities of residue left in no-till, or minimum till, fields retards soil warming and thus germination in the spring. Some say they can plant as much as three weeks earlier in areas where the residue has been removed. This has more importance today and in the future than it did in the past. Reduction in numbers of producers is expected to continue to rapidly decrease leaving the number of acres tended by a producer to increase.

- Even if it is a bad crop year, corn stover can still be harvested.

- Some of the herbicides applied are intercepted by the residue. Eventually most of it will be washed off by the rain and reach the ground, but removal of the residue should result in more uniform application and thus more consistent performance.

- Harvesting of stover can take place from shortly after harvest until the following spring. The tons per acre will likely decrease as time from harvest passes. Compaction when soils are not frozen or are wet would warrant serious consideration.

- The corn stover program can compare favorably with other value-added corn and bean programs in net return with little or no additional risk.

BOTTOM LINE

GLCC pays (11 – 15 miles) $15.00/Ton (1.5/Acre) = To the producer for providing the windrow		$22.50 / Acre
Nutrient replacement	=	$ 10.40
Net additional income	=	$12.10 / Acre
Savings of one field cultivator pass	=	$ 7.10
		$19.20
Normal profit without stover harvest		$24.19

Profit with stover $19.20 + $24.19 ***$43.39***

To prosper the producer must steadily increase net profit.
Corn stover is an opportunity to make a significant impact.

In the above example, profit is increased form $24.19 / Acre to $43.39 / Acre.

80% with little or no additional risk.

Interesting Points

Note: Although there are slightly different variations among soil scientists and nutrient experts, the "Interesting Points" listed below are intended to be middle of the road. They could be legitimately debated, but we believe at the end of the discussion most would still be intact.

- Based on present inputs from farmers, soil scientists and ISU agronomists, in many situations a partial corn stover harvest can provide a significant increase in the net return per acre with little or no additional risk.

- A 144.2 Bu. Yield would result in approximately 8,560 lbs. of corn stover, but would also produce a like amount of residue in the root systems (17,120 lbs. total stover and root residue). If 3,000 lbs. of stover were harvested per acre, it would equal 17.5 % of the total post-harvest corn plant.

- Nitrogen removed by harvesting corn stover may be of little if any value, when that field is being followed by planting soybeans or any other legume. These plants, unlike the corn plant, are able to take nitrogen from the air for their own growth and production and store even more for the crop that follows.

- There is approximately 33,000 tons of nitrogen in the air over every acre.

- If weather permits, harvesting of stover can take place from shortly after harvest until the following spring. The tonnage per acre will likely decrease as the time from harvest passes. Also, with the passage of time, rain will decrease potassium levels left in the residue by rinsing it from the stover.

- One ton of dry stover will create about 100# of humus that contains 5% nitrogen. A partial stover harvest may allow reduced tillage. Reducing tillage will increase humus near the soil's surface by increasing its longevity. Reducing tillage will have a greater positive effect on humus accumulation than the negative resulting from partial stover harvest.

- In the past, corn pickers removed ear corn from the field, which was later shelled, and most often the cobs were sold for other uses like furfural. The five-year period (1992 to 1996) estimated 144.2 bu. Corn crop yield on the high quality land in Shelby County would have had 2,018 lbs. of corn cobs per acre removed (1 bushel of ear corn = 70#, 56# of grain and 14# of cob).

- Each year technology, management and improved breeding increases the yield per acre. It has been estimated that corn yields have increased at a rate of over one additional bushel per acre per year for the past forty years. Along with each additional bushel of grain comes fifty-six pounds of additional stover. That is an addition of over one ton.

- Large quantities of residue left in no till or minimum till fields retard soil warming and thus germination in the spring. This is especially true in situations with corn following corn and hybrids with low cold tolerance. Some say they can plant as much as three weeks earlier in fields where residue has been removed.

- Some of the herbicides applied are intercepted by residue. Eventually most of it will be washed off by the rain and reach the ground. Harvesting residue may result in more uniform application and more consistent herbicide performance.

- Harvesting stover from your field does not eliminate the potential of running cattle or sheep to glean dropped ears of corn after stover is partially harvested. The weight of the full ear is often heavy enough to escape stover harvesting methods and GLCC prefers not having the ears of corn as the grain contains very little furfural. Most often livestock are placed in fields to pickup the otherwise lost ears of corn. The livestock consumes less than 1,000 pounds of actual stover per acre.

- 95% of plant food is taken from the air. The remaining 5% is taken from the soil.

- Bales from stover harvested when windrows are left behind the combine are most often heavier than those bales taken from a total stover harvest. An eight-row head on the combine will produce heavier bales taken from the windrow than a four-row head.

- It has been calculated from a nutrients removed standpoint, selling stalks for $35.60/per dry ton would be similar to selling alfalfa hay in large round bales at near $100/per ton.

- Root carbon contributes more to organic matter than does the stover (Campbell, et al. 1991).

- It is Great Lakes' goal to make corn stover a viable raw material supply for the Omaha plant while adding to the income of the corn producer. "IT

Appendix B 2
Sample Corn Stover Harvest Commitment

Contract__________

Producer____
First Middle Last

Address: ____
Street Address City State Zip Code

Phone: (___ _)________________(_____)___________________(___)___________________
Home Shop/Business Cellular

Field No.	State	County	Town ship	Section	Removal Deadline	# of Acres	Harvest method		Done By		Est. Mi. to Harlan Plant	Bales for own use
							W	E	S	G		

W= WINDROW, E=ENTIRE FIELD, S= SELF, G= GLCC

MAP

Please draw a detailed map of the farm.

- Describe location, surrounding crops, road names or numbers, water ways and other land marks.
- Identify by number each corn field where stover is to be harvested.
- This map represents one section of land and each small box is 40 acres.
- Use a * to recommend a bale staging location.
- Identify entrances to the field.

Additional maps may be attached for fields located in other sections but operated by the same producer.

S

Producer:_______________________________GLCC:__________________________________
Signature Date Signature Date

Checks will be made out to one Producer only

Sample of 1997-98 Corn Stover Harvest Commitment (back of form)

NOTE: Early sign up is necessary to allow GLCC time to arrange for balers, stagers and haulers and be ready as soon as the corn harvest begins.

- GLCC penalty if stover is not removed by agreed upon deadline:

Deadline	**Penalty**
Apr 1st	\$15/acre
Mar 1st	\$12/acre
Feb 1st	\$10/acre
Jan 1st	\$ 8/acre
Dec 1st	\$ 6/acre

- If producer wishes to keep some bales for himself, GLCC must be notified prior to harvest. The producer's account will be charged \$9 per round or large square bales and \$6 per intermediate square bale. The producer is responsible for staging these and for informing the haulers so that they do not remove those bales wanted by the producer.

- If producer has a preferred baler, every effort will be made to use them.

- Producer must call GLCC with Contract No. and Field No. when grain harvest is completed in each committed field. GLCC, baler, producer and trucker must communicate to coordinate efforts.

- Cows should not be in the field with bales, nor should field work be done around bales. If it is necessary to run your cattle or do fieldwork in advance of hauling, the producer should call GLCC and make arrangements or stage the bales.

- If baling has not been completed and the producer wishes to do field work or run cows, he should do so at his discretion. However, if this is done, this commitment is canceled.

- Payments to the producers may vary. Yields and payments depend on the amount of stover available. Yield and payment variations are as follows: Hybrid, Population, Yield, Ridges, Cultivation Practice, Baler Operator and Distance.

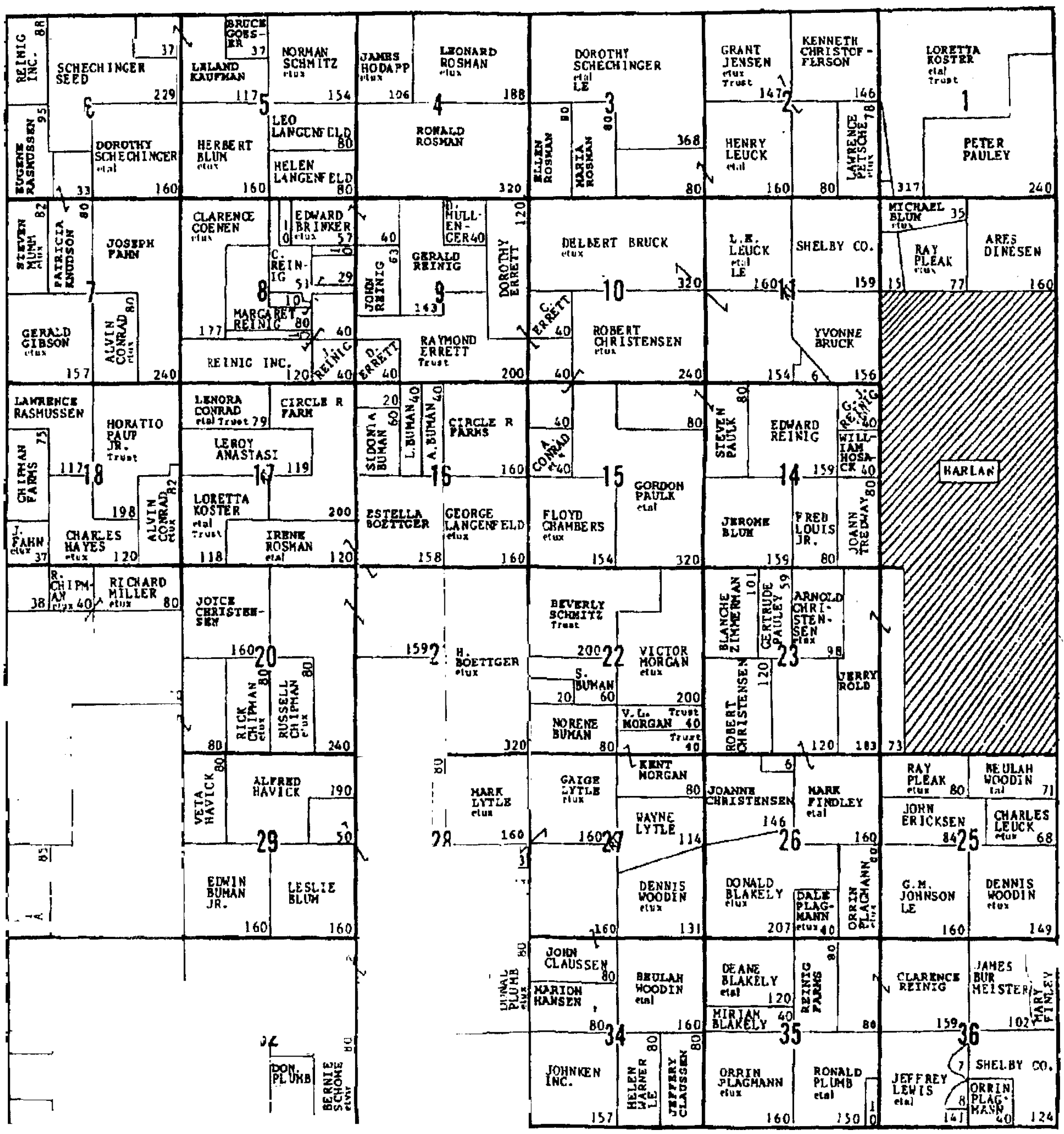
- We pay on a dry ton (100% dry matter) basis.

- Special instructions from the producer.

APPENDIX C1

FIELD PLAT MAP

LINCOLN PLAT

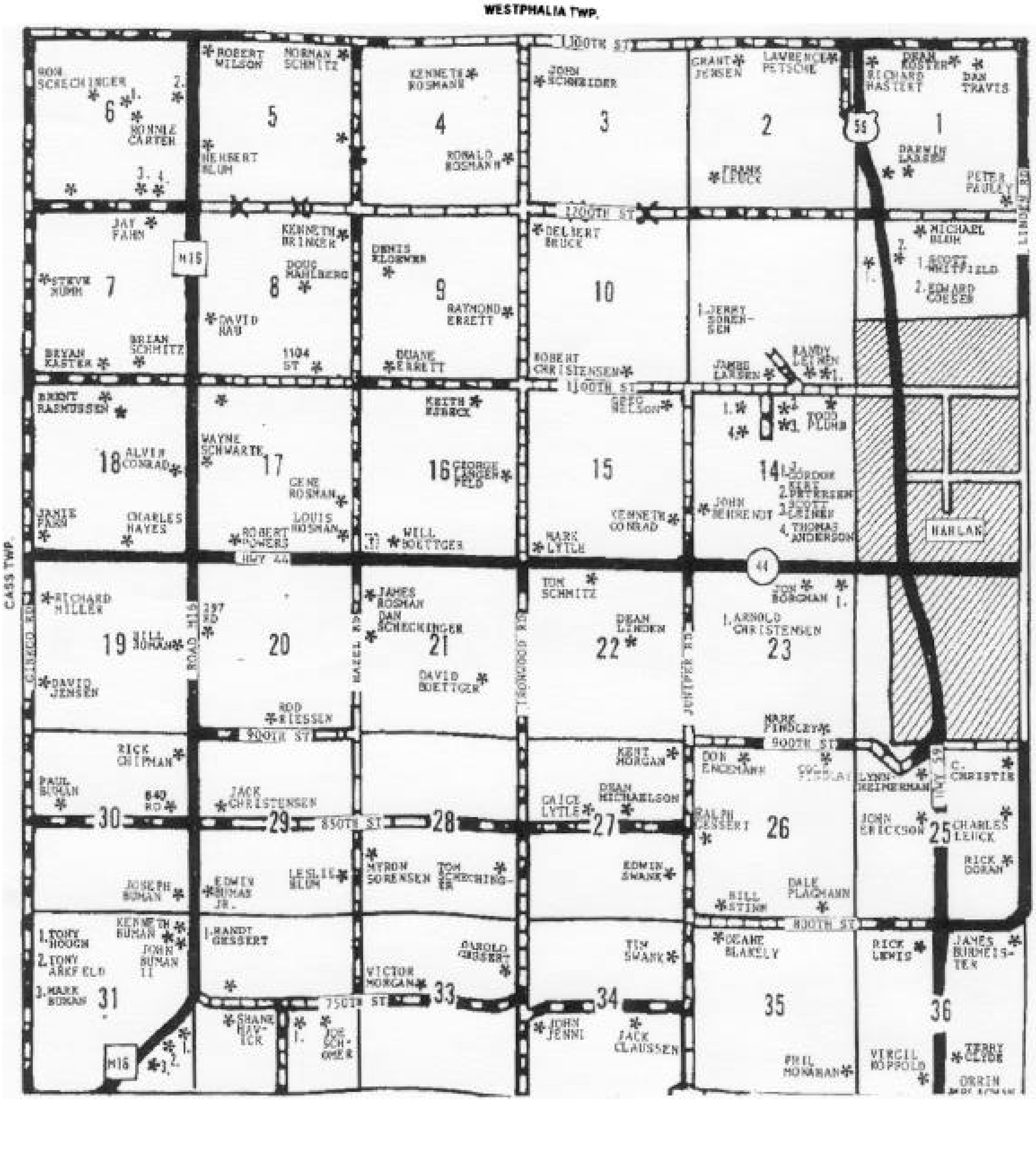


APPENDIX C 2

DIRECTORY EXAMPLE

LINCOLN DIRECTORY

WESTPHALIA TWP.



APPENDIX D

BALING CONTRACT

BALER AGREES TO:

- Bale in accordance with the producer commitment. In most cases this will be a windrow left behind the combine.
- Attempt to finish baling at least 10 days before the deadline date on the Producer's Commitment to allow time for removal from the field and trucking.
- Make a genuine effort to bale accepted acres, giving top priority to GLCC during the stover harvest, and not allowing other work to interfere.
- Wrap round bales with 3 wraps minimum of plastic mesh. Rectangular bales to use GLCC twine or equivalent: 380# knot strength for 3X3X8 and 500# knot strength for 4X4X8.
- Work closely with GLCC and the Producer. The producer's satisfaction is of prime importance. A cell phone would be desirable. Communications with GLCC and Producer is extremely important. Any changes in plans or any delays should be communicated.
- Not to bale if the moisture is above 30% or the producer does not want you in the field.
- Assume responsibility for bales broken during baling (especially if excessive).

Assume responsibility to meet the producer's deadline date, <u>if applicable</u>.

GLCC AGREES TO:

- GLCC will pay baler an interim pay upon completion of fields based on 1,000 pounds of dry matter per bale for large round and large 4X4 square bales, and 500 pounds for intermediate 3X3. The remainder of the amount due will be paid after delivery to the GLCC plant is completed.
- Provide plastic wrap and twine at wholesale.
- Assign acres to each baling machine. The baler will decide how much he wants to be responsible for.
- If a baler does not have his assigned acres completed when other balers complete their assignments, they may be instructed to complete those acres not yet completed.
- Every effort will be made to schedule in advance so balers can plan ahead.
- Provide copies of the producer commitment to the baler – complete with maps and description.

Total acres requested and accepted____

Baler

Great Lakes Chemical Corporation ____

(continued on reverse)

Baler agrees that in the event he does not make a sincere effort to complete the baling for the following commitment(s):

Cont..# & Field# Initial	Cont..# & Field# Initial	Cont..# & Field# Initial	Cont..# & Field# Initial	Cont..# & Field# Initial

Baler will cause damage to Great Lakes Chemical Corporation in the amount of:____________________ and agrees to reimburse GLCC for said damages. However, it is understood by GLCC that delays in baling due to weather or illness (with doctor's release) will not be assessed any damage.

GLCC reserves the right to reassign commitments to other balers, if it is felt by GLCC that the baling is not being completed in a timely fashion.

Signature of Baler__________________________________

Signature of GLCC Representative_________________________________

Print Name ____________________________________

Address_______________________________________

City/State/Zip__________________________________

Phone____

Cell Phone____________________________________

APPENDIX E

HAULER'S COMMITMENT

HAULER AGREES:

- Work closely with GLCC and the Producers. The Producer's satisfaction is of prime importance. Always treat producers respectfully.
- To pick-up and haul stover bales from the producer's fields as designated by GLCC in a timely manner.
- Maintain frequent communications with GLCC concerning the status of the hauling. A cellular phone would be desirable. Any changes in plans or any delays should be communicated.
- To minimize ruts or field tracking (communicate with the producer if there are any question).
- Note potential problems in producer's field or breakage not removed and report it to GLCC immediately, so when possible the problem can be solved or avoided.
- Help solve and prevent problems.
- Hauler requests _________________ number of loads containing an estimated __________tons per load and plans the following number of loads in ________ October, __________November, __________ December, ____________ After Dec.

The above request by hauler for this number of loads is not to be a guarantee by GLCC, but rather a guide to help GLCC establish the number of haulers needed to complete the task.

GLCC AGREES:

- Assign the hauling to the various haulers in accordance with the producer commitments and this hauling agreement.
- To provide copies of the needed information to the hauler, complete with maps and location descriptions.
- To reserve the right to bring in additional haulers if GLCC feels hauling by present haulers is not progressing in a timely fashion.

NAME______________________________________

ADDRESS__________________________________

PHONE_____________________________________

CELL PHONE________________________________

____

____

GLCC REPRESENTATIVE HAULER